Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins

Part 4: Lower Columbia Coho

September 2007

Paul McElhany[1], Mark Chilcote[2], James Myers[1], Ray Beamesderfer[3]

[1] National Marine Fisheries Service Northwest Fisheries Science Center
[2] Oregon Department of Fish and Wildlife
[3] Cramer Fish Sciences

Prepared for
Oregon Department of Fish and Wildlife and
National Marine Fisheries Service

Table of Contents

I. ESU Overview and Historical Range 3
II. Abundance and Productivity 5
    A&P – Youngs Bay 5
    A&P – Big Creek 7
    A&P – Clatskanie River 7
    A&P – Scappoose Creek 10
    A&P – Clackamas River 12
    A&P – Sandy River 19
    A&P – Lower Gorge Tributaries 26
    A&P – Hood River/Upper Gorge Tributaries 26
  A&P – Criterion Summary 29
III. Spatial Structure 30
    SS – Youngs Bay 30
    SS – Big Creek 31
    SS – Clatskanie River 32
    SS – Scappoose Creek 33
    SS – Clackamas River 34
    SS – Sandy River 35
    SS – Lower Gorge Tributaries 36
    SS – Hood River/Upper Gorge Tributaries 37
  SS – Criterion Summary 39
IV. Diversity Overview 41
    DV – Youngs Bay 42
    DV – Big Creek 43
    DV – Clatskanie River 44
    DV – Scappoose Creek 45
    DV – Clackamas River 46
    DV – Sandy River 48
    DV – Lower Gorge Tributaries 50
    DV – Hood River/Upper Gorge Tributaries 52
  DV – Criterion Summary 54
V. Summary of Population Results 55
Literature Cited 57

I. ESU Overview and Historical Range

The Lower Columbia River (LCR) Coho ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (Figure 1). The boundaries for this ESU do not extend into upper Willamette portion of the LCR basin, because Willamette Falls (near Portland) was a natural barrier to fall migrating salmonids such as coho salmon.

In general, wild coho in the Columbia basin have been in decline for the last 75 years. The number of wild coho returning to the Columbia River historically was at least 600,000 fish (Chapman, 1986). As recently as 1996, the total return of wild fish may have been as few as 400 fish (Chilcote, 1999). Coinciding with this decline in total abundance has been a reduction in the number of functioning wild populations. All Columbia basin populations upstream of Hood River were extirpated nearly 50 years ago. Of the 25 historical populations that comprised the LCR ESU, only in the Clackamas and Sandy Rivers, is there direct evidence that coho production is not reproductively dependent on the spawning of stray hatchery fish. However, in the last 5 years there has been an increase in the abundance of wild coho in Clackamas and Sandy, plus a re-appearance of moderate numbers wild coho in the Scappoose and Clatskanie basins after a 10-year period in the 1990s when they were largely absent. Additionally, there have been efforts to reestablish coho salmon in the upper Columbia and Snake rivers.

Against this backdrop, we have performed the following status assessment of the eight coho populations that occur within Oregon's portion of the LCR ESU. They include: Youngs Bay, Big Creek, Clatskanie River, Scappoose Creek, Clackamas River, Sandy River, Lower Gorge and Hood River/Upper Gorge. Our assessment consists of three components, each of which evaluates one of the viability criteria (i.e., abundance and productivity, spatial structure, and diversity). This is then followed by a synthesis section where we pool the results from these criteria evaluations into a status rating for each population. Finally, we present an interpretation of the population results in terms of the overall status of Oregon's LCR coho populations and the LCR ESU as a whole.

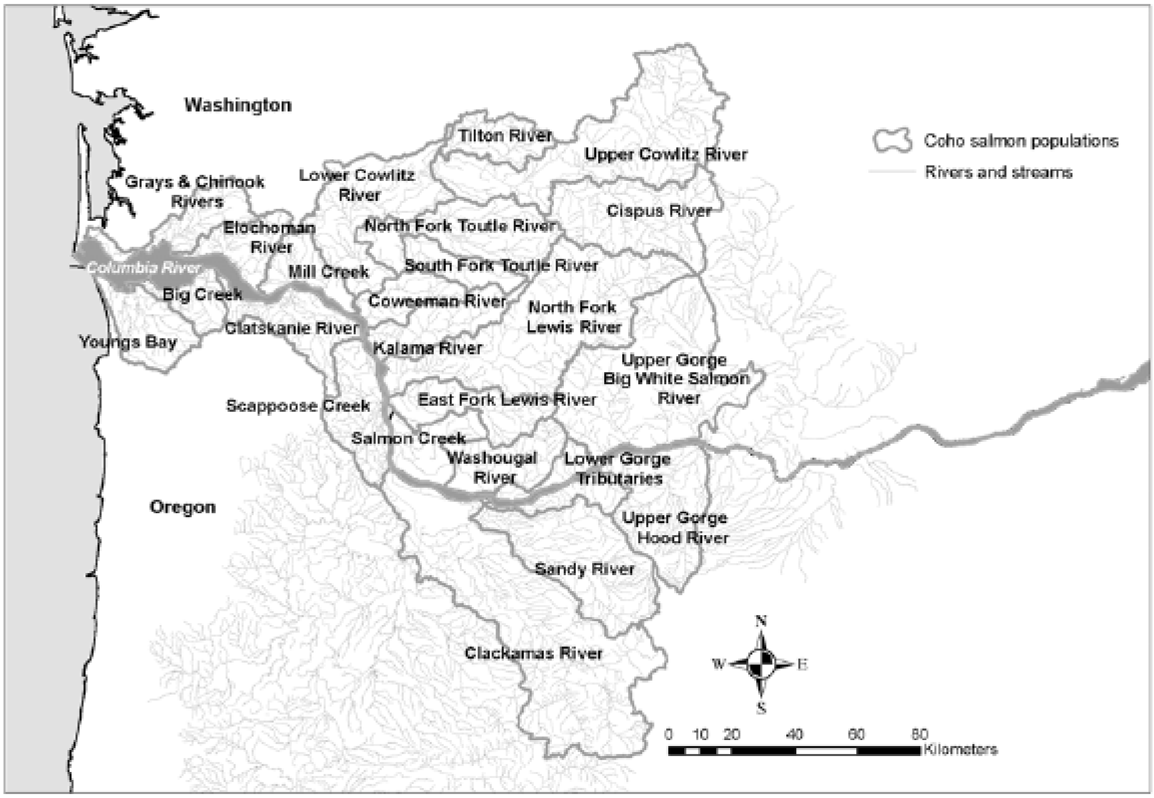


Figure 1: Map of Lower Columbia River coho salmon populations.

II. Abundance and Productivity

A&P – Youngs Bay

ODFW has conducted a peak count of live and dead adult coho at an index site in Youngs Bay since 1949 (Figure 2). The count does not distinguish between hatchery and naturally produced fish and it is not appropriate to conduct a time series analysis with these data. However, the data do indicate that the population has been at low abundance and during the 1990s there were years with no observed coho.

Starting in 2002, a stratified random sample survey has been conducted (Suring et al. 2006), allowing estimation of population size (Figure 3) and hatchery fraction (Figure 4). The random sample estimates abundance for the Astoria population group, which includes both the Youngs Bay and Big Creek populations used in our analysis. The random survey indicates that the number of natural origin spawners is small, with a geometric mean of about 200 fish, which is in the 'extirpated or nearly so' minimum abundance threshold category. The population is dominated by hatchery fish, with on average at least 80% of the coho of hatchery origin. Random survey results show that both the Youngs Bay and Big Creek portions of the Astoria population group have high proportions of hatchery fish. Taken together, these data indicate little, if any natural productivity of coho in the Youngs Bay population and we consider the population most likely in the 'extirpated or nearly so' or 'high risk' category. The Oregon Native Fish Status report (ODFW 2005) listed this population as "fail" for abundance and "fail" for productivity.

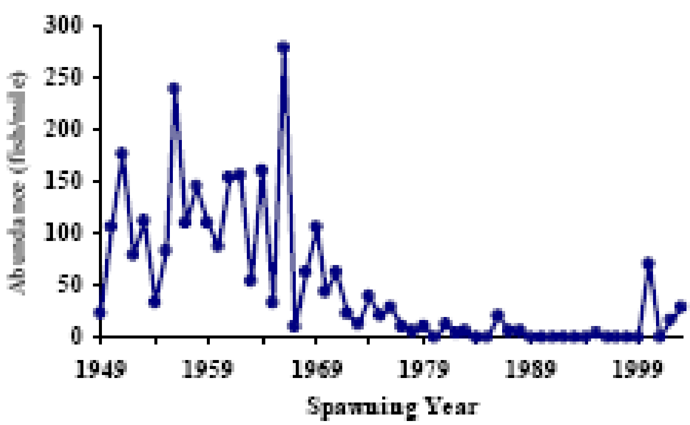


Figure 2: Peak counts of live and dead fish in an index reach in the Youngs Bay coho salmon population (reproduced from (ODFW 2005).

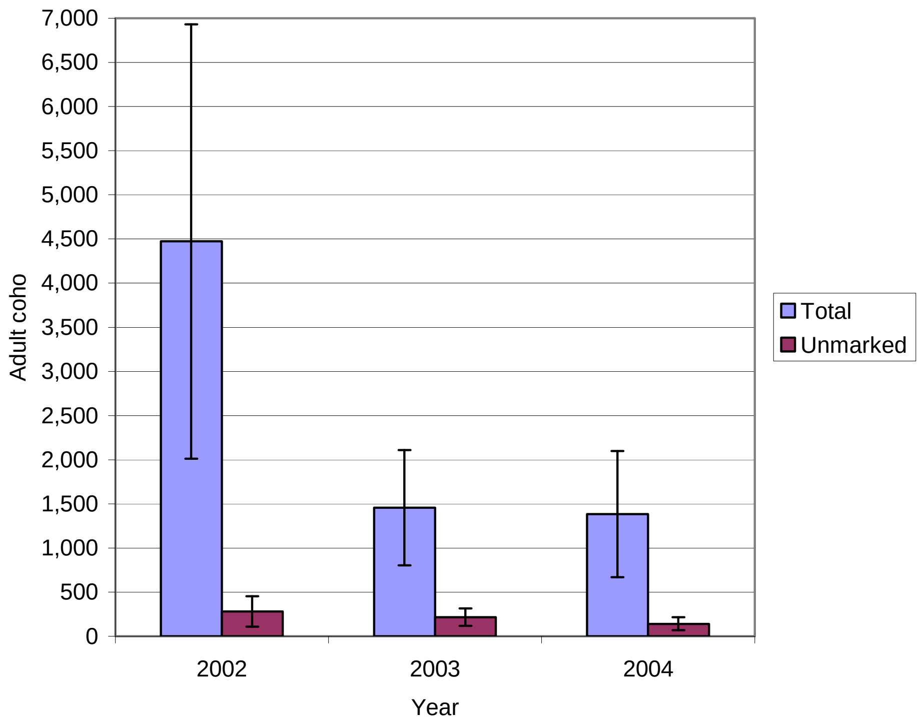


Figure 3: Abundance estimates of adult coho salmon in Astoria population group (Suring et al. 2006). The 'Total' bars show the estimated total adult coho salmon abundance. The 'Unmarked' bars indicate potential natural origin fish (some unmarked fish are likely of hatchery origin). The error bars are 95% confidence intervals.

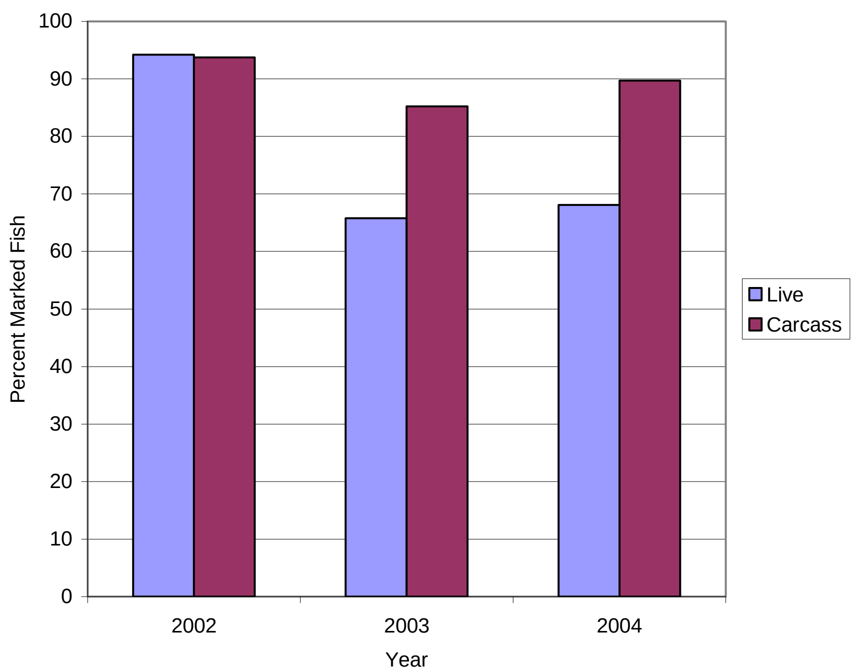


Figure 4: Percent of hatchery marked fish in the Astoria population group (Youngs Bay and Big Creek populations in this document) based on observations of either live fish or carcasses (Suring et al. 2006). Values are adjusted for mark rates of local hatchery releases.

A&P – Big Creek

ODFW has conducted a peak count of live and dead adult coho at an index site in Big Creek since 1950 (Figure 5). The count does not distinguish between hatchery and naturally produced fish and it is not appropriate to conduct a time series analysis with these data. However, the data do indicate that the population has been at low abundance and in many years there were no observed coho.

Starting in 2002, a stratified random sample survey has been conducted (Suring et al. 2006), allowing estimation of population size (Figure 3) and hatchery fraction (Figure 4). The random sample estimates abundance for the Astoria population group, which includes both the Youngs Bay and Big Creek populations used in our analysis. The random survey indicates that the number of natural origin spawners for Youngs Bay and Big creek combined is small, with a geometric mean of about 200 fish, which is in the 'extirpated or nearly so' minimum abundance threshold category. The population is dominated by hatchery fish, with on average at least 80% of the coho of hatchery origin. Random survey results show that both the Youngs Bay and Big Creek portions of the Astoria population group have high proportions of hatchery fish. Taken together, these data indicate little, if any natural productivity of coho in the Big Creek population and we consider the population most likely in the 'extirpated or nearly so' or 'high risk' category. The Oregon Native Fish Status report (ODFW 2005) listed this population as "fail" for abundance and "fail" for productivity.

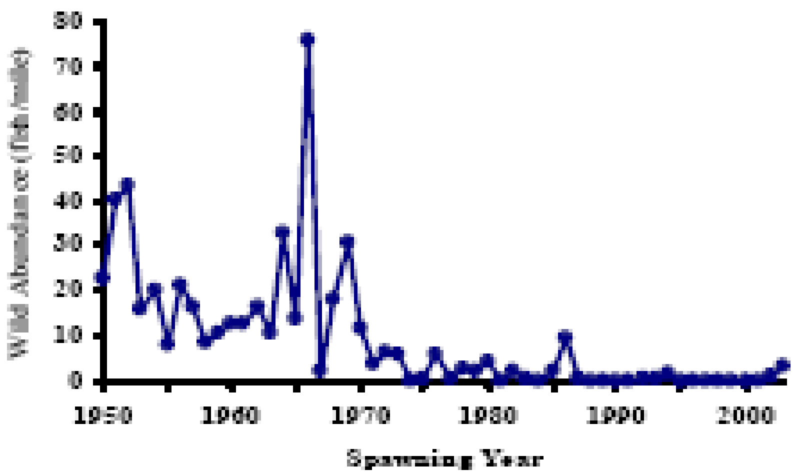


Figure 5: Peak counts of live and dead fish in an index reach in the Big Creek coho salmon population (reproduced from ODFW 2005).

A&P – Clatskanie River

ODFW has conducted a peak count of live and dead adult coho at an index site in the Clatskanie since 1949 (Figure 5). The count does not distinguish between hatchery and naturally produced fish and it is not appropriate to conduct a time series analysis with these data. However, the data do indicate that the population has been at low abundance and in many years there were no observed adult coho (although juveniles were observed in subsequent years – indicating that a small number of adults were present). Starting in 2002, a stratified random sample survey has been conducted (Suring et al. 2006), allowing estimation of population size (Figure 7) and hatchery fraction (Figure 8). The random survey indicates that the number of natural origin spawners for the Clatskanie population is small, with a three year geometric mean of 286 fish, which is in the 'extirpated or nearly so' minimum abundance threshold category. The hatchery fraction data are highly variable, ranging from 80% hatchery fish to 0% hatchery fish, depending on the year. The temporal variability is likely a reflection of the spatial hatchery fraction pattern combined with the particulars of the sampling protocol (Suring et al. 2006). The streams in the western portion of the population area are dominated by hatchery fish, whereas the Clatskanie River itself, in the eastern portion of the population area, appears to be free of hatchery fish. Because there are some returning adults and there do not appear to be many hatchery fish in most of the population area, there is likely some natural production in the Clatskanie. However, the population is currently small and likely dropped to double or single digits in the recent past. Therefore, we consider the population as most likely in the 'high risk' category' but with substantial possibility it is in the 'extirpated or nearly so' category. The Oregon Native Fish Status report (ODFW 2005) listed this population as "fail" for abundance and "fail" for productivity.

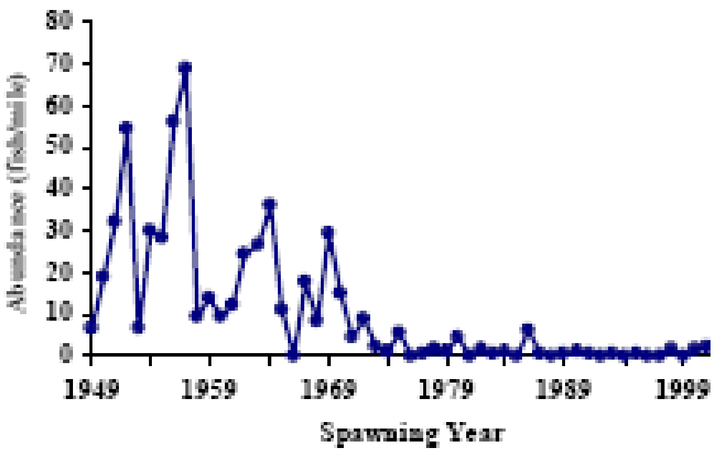


Figure 6: Peak counts of live and dead fish in an index reach in the Clatskanie River coho salmon population (reproduced from ODFW 2005).

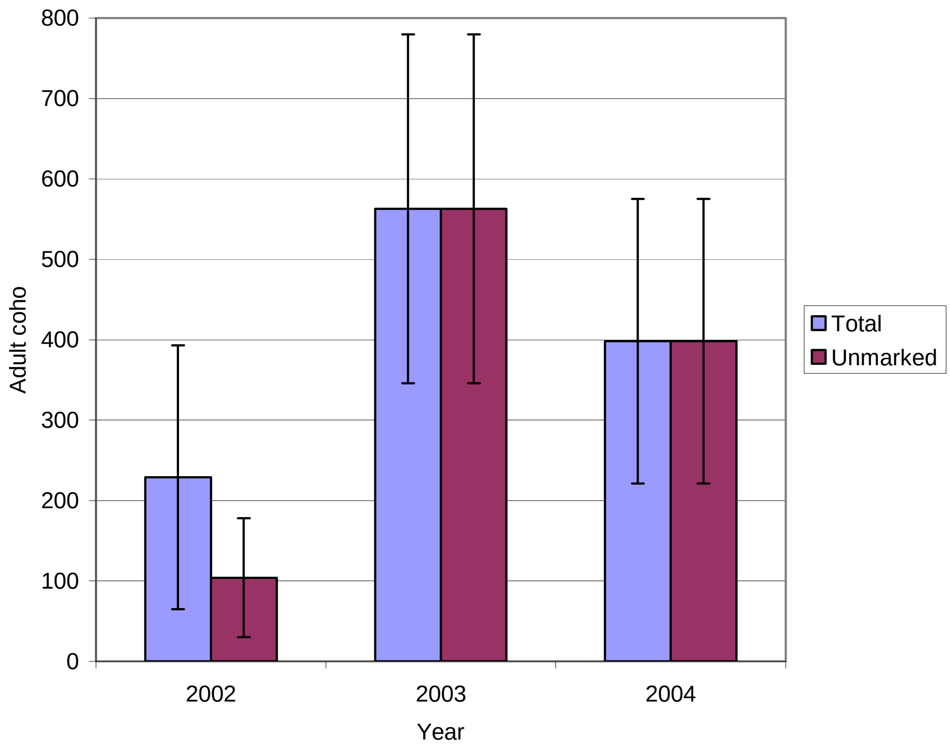


Figure 7: Abundance estimates of adult coho salmon in Clatskanie population (Suring et al. 2006). The 'Total' bars show the estimated total adult coho salmon abundance. The 'Unmarked' bars indicate potential natural origin fish (some unmarked fish are likely of hatchery origin). The error bars are 95% confidence intervals.

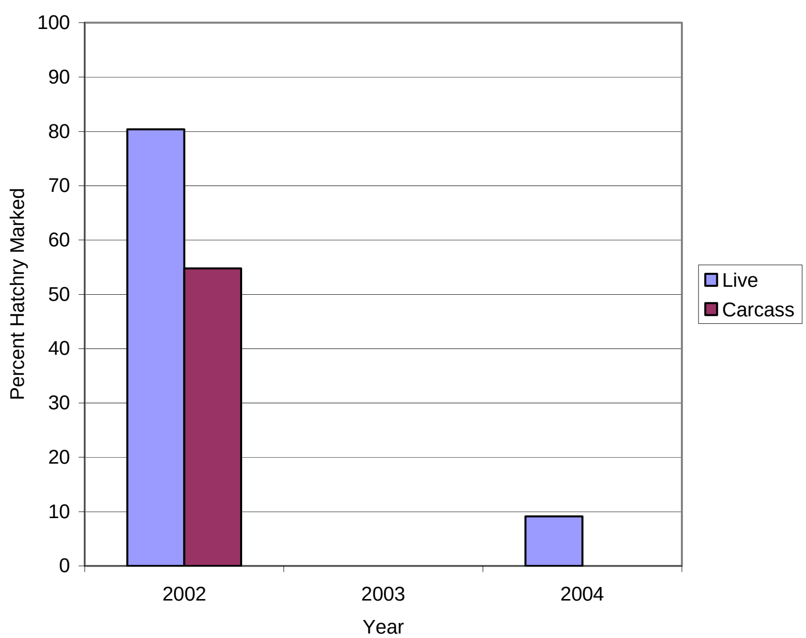


Figure 8: Percent of hatchery marked fish in the Clatskanie population group based on observations of either live fish or carcasses (Suring et al. 2006). Values are adjusted for mark rates of local hatchery releases.

A&P – Scappoose Creek

ODFW has conducted a peak count of live and dead adult coho at an index site in the Scappoose since 1950 (Figure 9). The count does not distinguish between hatchery and naturally produced fish and it is not appropriate to conduct a time series analysis with these data. However, the data do indicate that the population has been at low abundance and in many years there were no observed adult coho. Starting in 2002, a stratified random sample survey has been conducted (Suring et al. 2006), allowing estimation of population size (Figure 10) and hatchery fraction (Figure 11). The random survey indicates that the number of natural origin spawners for the Scappoose population is relatively small, with a three year geometric mean of 470 fish, which is in the 'extirpated or nearly so' minimum abundance threshold category, but approaching the 'high risk' category. The hatchery fraction data indicate that there are currently few hatchery fish in this population. Because there are several hundred returning adults and there do not appear to be many hatchery fish in the population, there is likely some natural production of coho in the Scappoose. However, the population is currently small and likely dropped to double or single digits in the recent past. Therefore, we consider the population as most likely in the 'high risk' category but with a possibility it is in the 'extirpated or nearly so' category. The Oregon Native Fish Status report (ODFW 2005) listed this population as "fail" for abundance and "fail" for productivity.

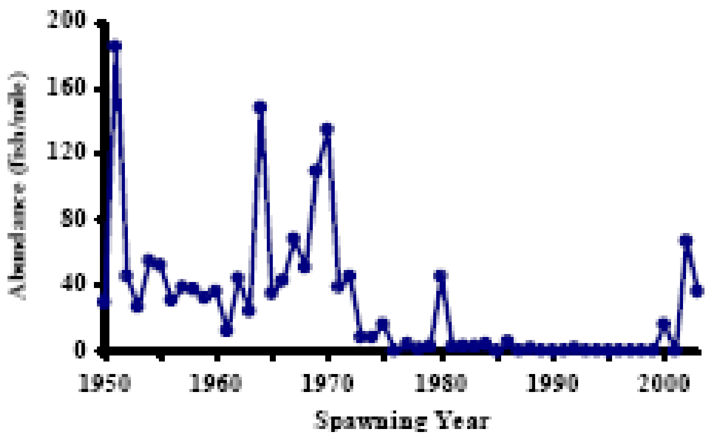


Figure 9: Peak counts of live and dead fish in an index reach in the Scappoose coho salmon population (reproduced from ODFW 2005).

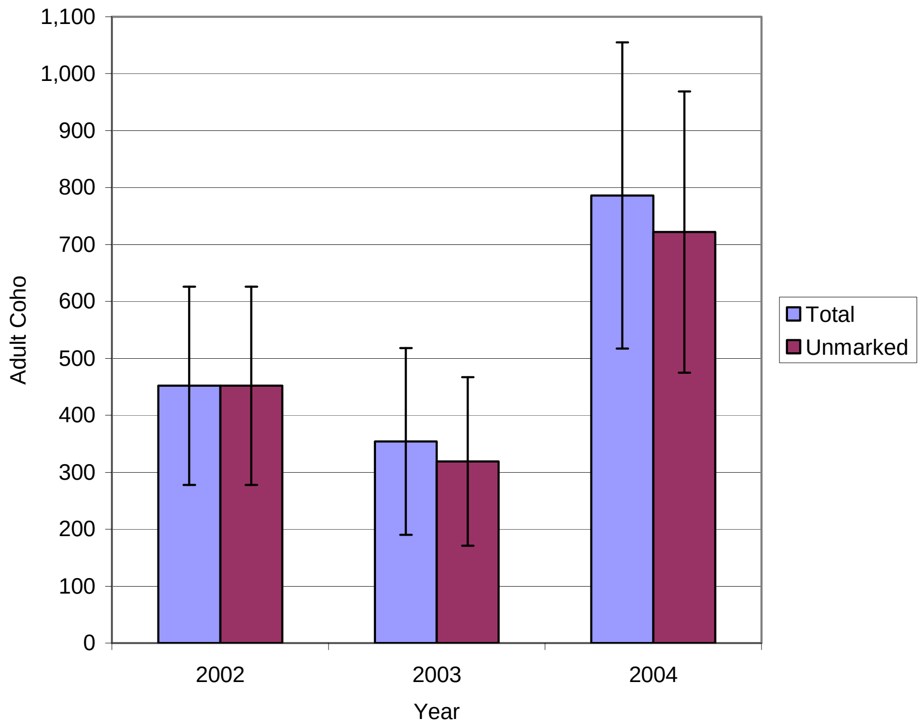


Figure 10: Abundance estimates of adult coho salmon in Scappoose population (Suring et al. 2006). The 'Total' bars show the estimated total adult coho salmon abundance. The 'Unmarked' bars indicate potential natural origin fish (some unmarked fish are likely of hatchery origin). The error bars are 95% confidence intervals.

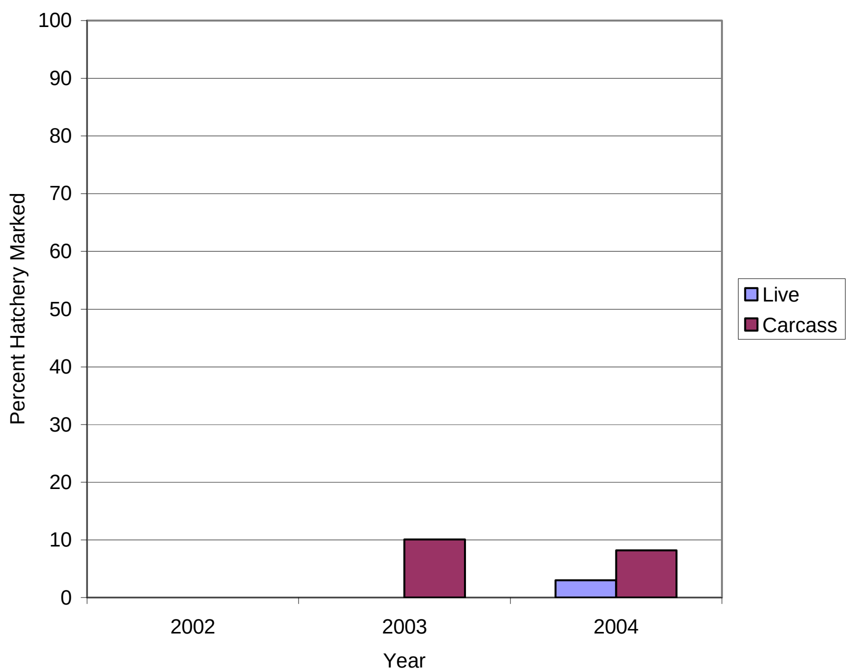


Figure 11: Percent of hatchery marked fish in the Scappoose population group based on observations of either live fish or carcasses (Suring et al. 2006). Values are adjusted for mark rates of local hatchery releases.

A&P – Clackamas River

A time series of abundance sufficient for quantitative analysis is available for the Clackamas population (Appendix B). Descriptive graphs and viability analysis results are provided in Figure 12 to Figure 20 and in Table 1 to Table 4. The population long-term geometric mean is about 1,700 natural origin spawners, which is in the high risk minimum abundance threshold category (Table 1). (Note: Coho have the highest minimum abundance thresholds because of high variability and a discrete age structure that does not provide temporal buffering of risk.) Because coho have discrete three year generations, it is useful to look at the abundance patterns for individual cohorts (Figure 13). The data show that cohort A (ending in 2005) is likely at greater risk than the other two cohorts because it has a lower average abundance. The average recent hatchery fraction is estimated at about 25%, making it difficult to obtain a precise estimate of population productivity. The pre-harvest viability curve analysis, the CAPM modeling and the PopCycle model all suggest that the population is currently viable, and perhaps in the very low risk category. The escapement viability curve suggests that the population continued to experience a pattern of harvest similar to the available time series (average impact rate of 73%) would most likely be in the 'extirpated or nearly so' risk category. However, this analysis included years when the fishing mortality was in excess of 80% and therefore incorporates a larger reduction in life history survival than the 25% fishery impact rates that are expected in the future. The Oregon Native Fish Status report (ODFW 2005), which divided the Clackamas River coho into 'early' and 'late' populations, classified both as "passing " interim criteria for abundance and productivity. Based on our evaluation, we conclude that this population is most likely in the low risk category, for the abundance and productivity criterion.

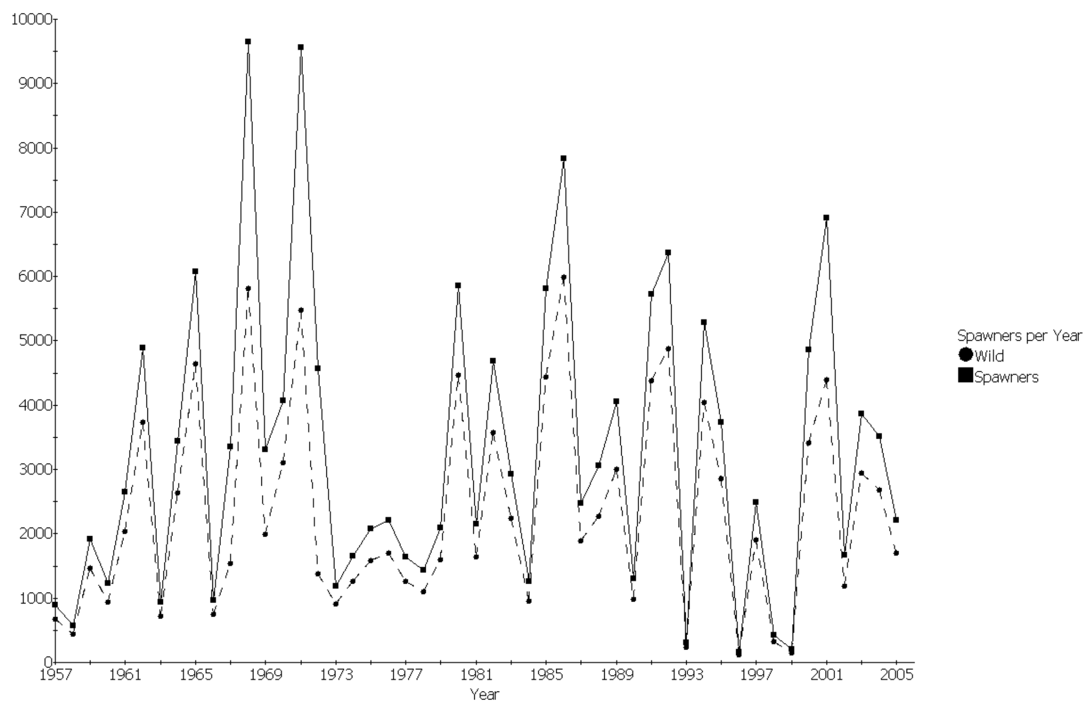


Figure 12: Clackamas River coho salmon abundance.

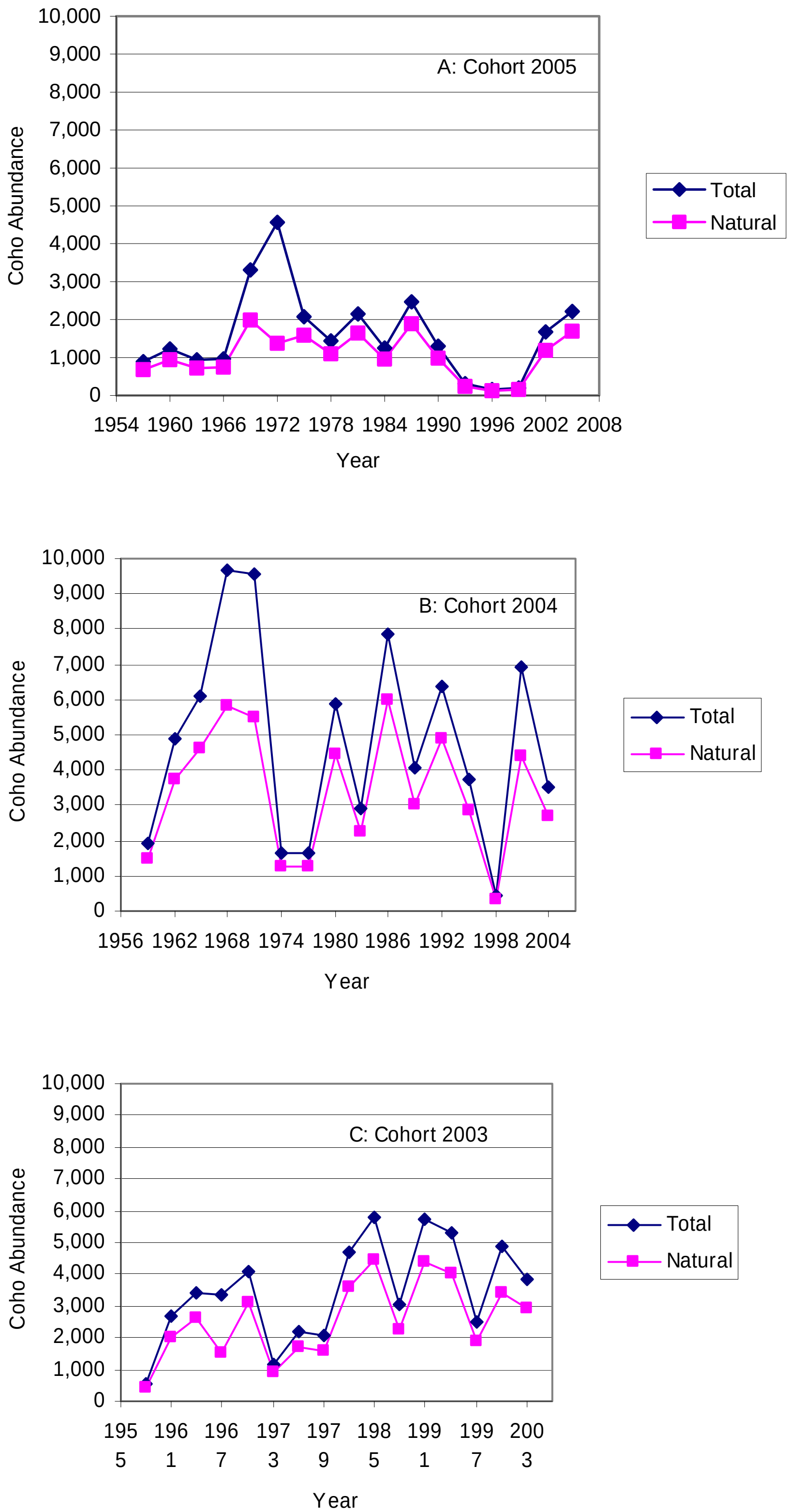


Figure 13: Clackamas River coho salmon abundance by cohort. The geometric mean natural origin abundance for cohort A is 828; for cohort B it is 2,211; and for cohort C it is 2,772.

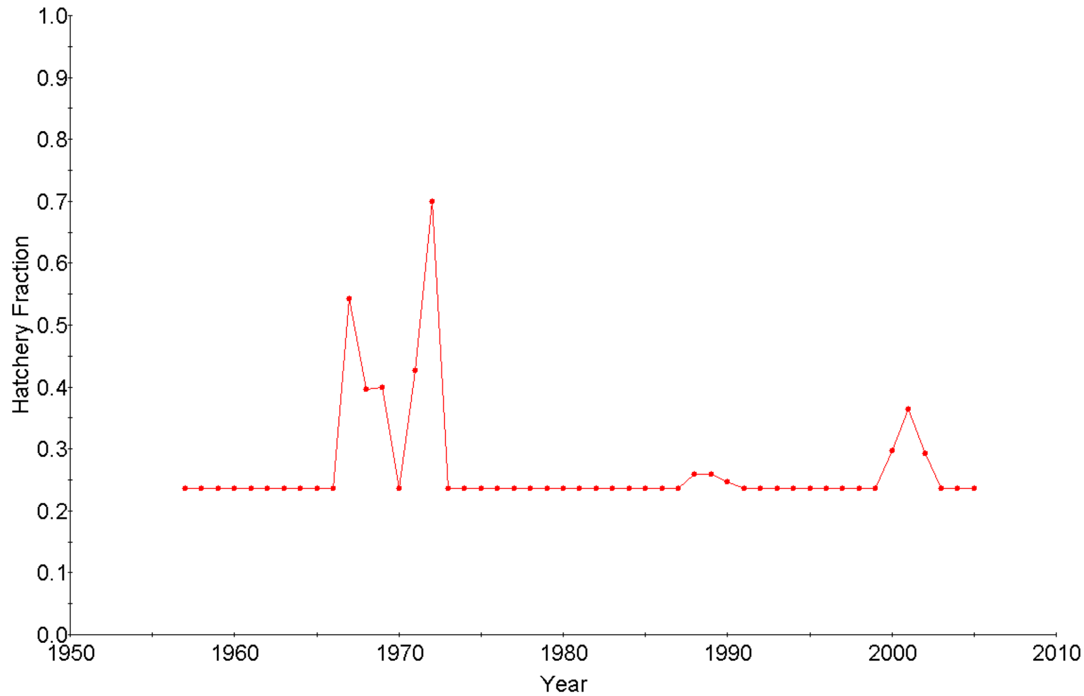


Figure 14: Clackamas River coho salmon hatchery fraction.

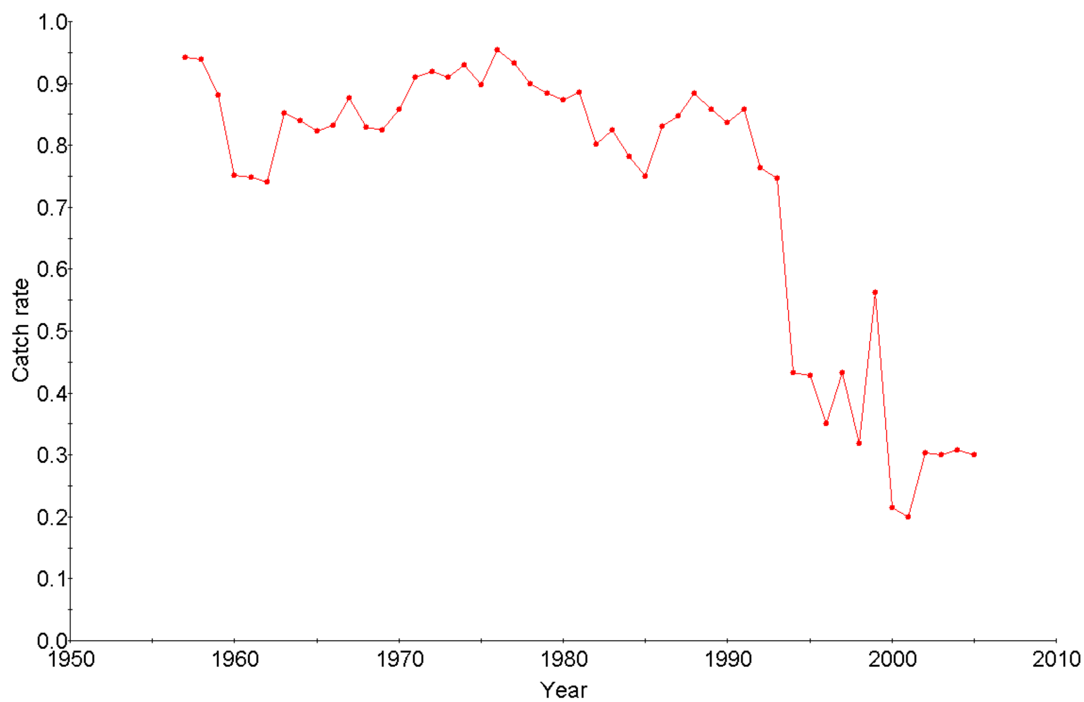


Figure 15: Clackamas River coho harvest rate.

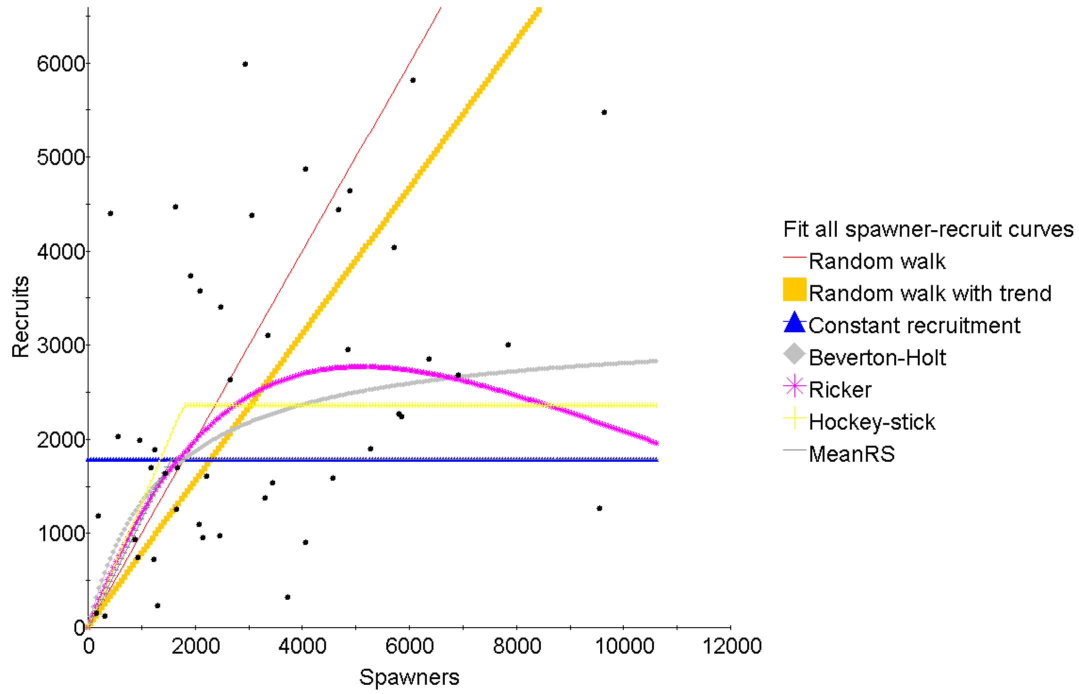


Figure 16: Clackamas River coho salmon escapement recruitment functions.

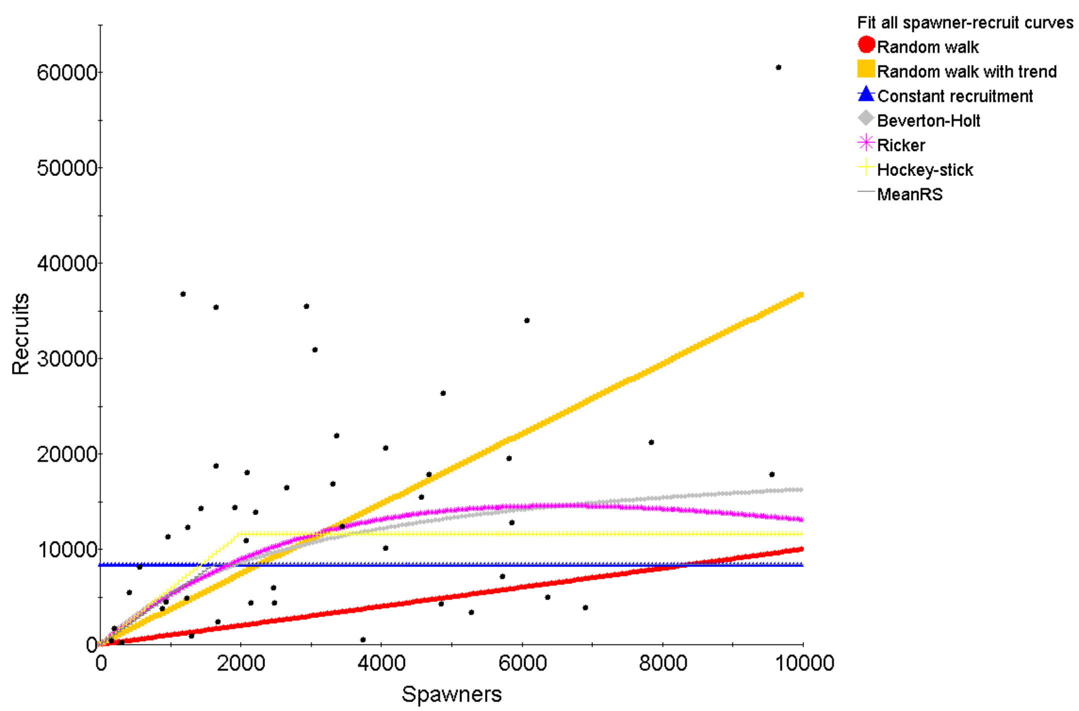


Figure 17: Clackamas River coho salmon pre-harvest recruitment functions.

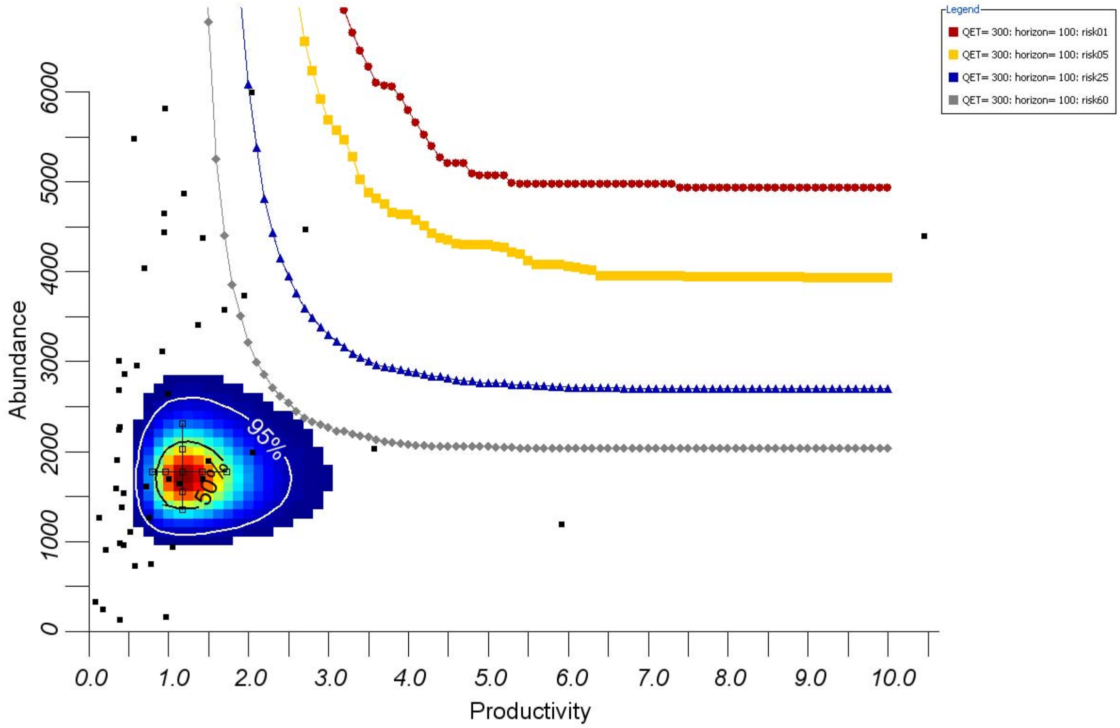


Figure 18: Clackamas River coho salmon escapement viability curve.

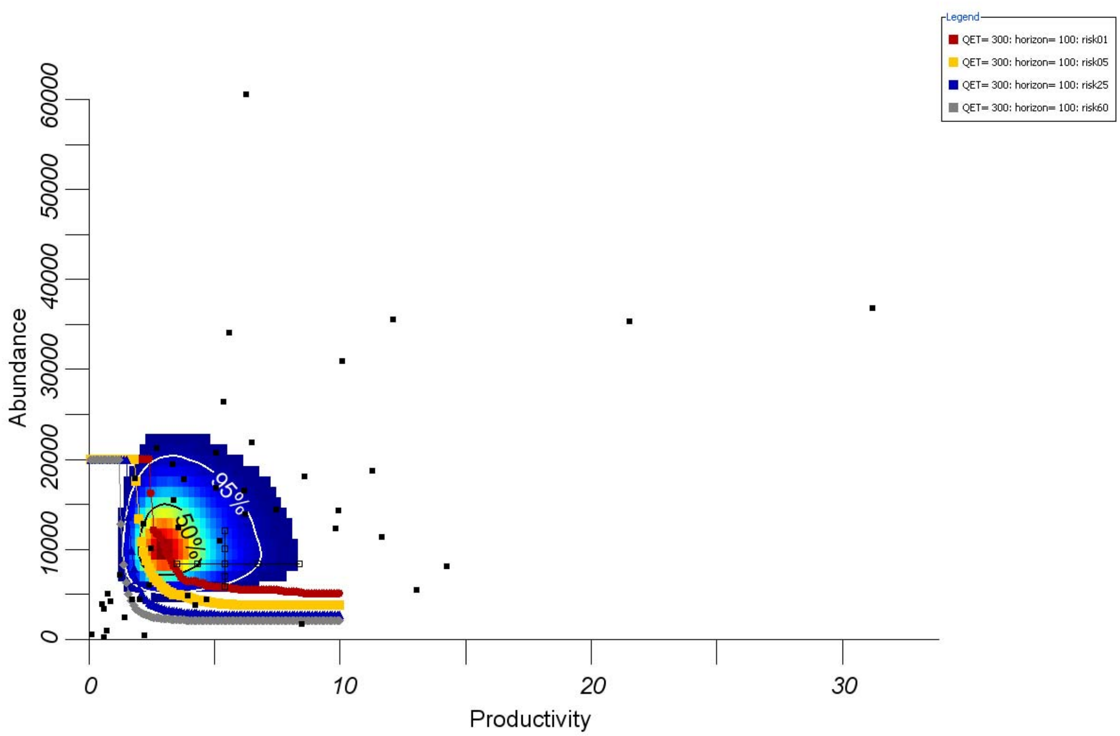


Figure 19: Clackamas River coho salmon pre-harvest viability curve showing all data points.

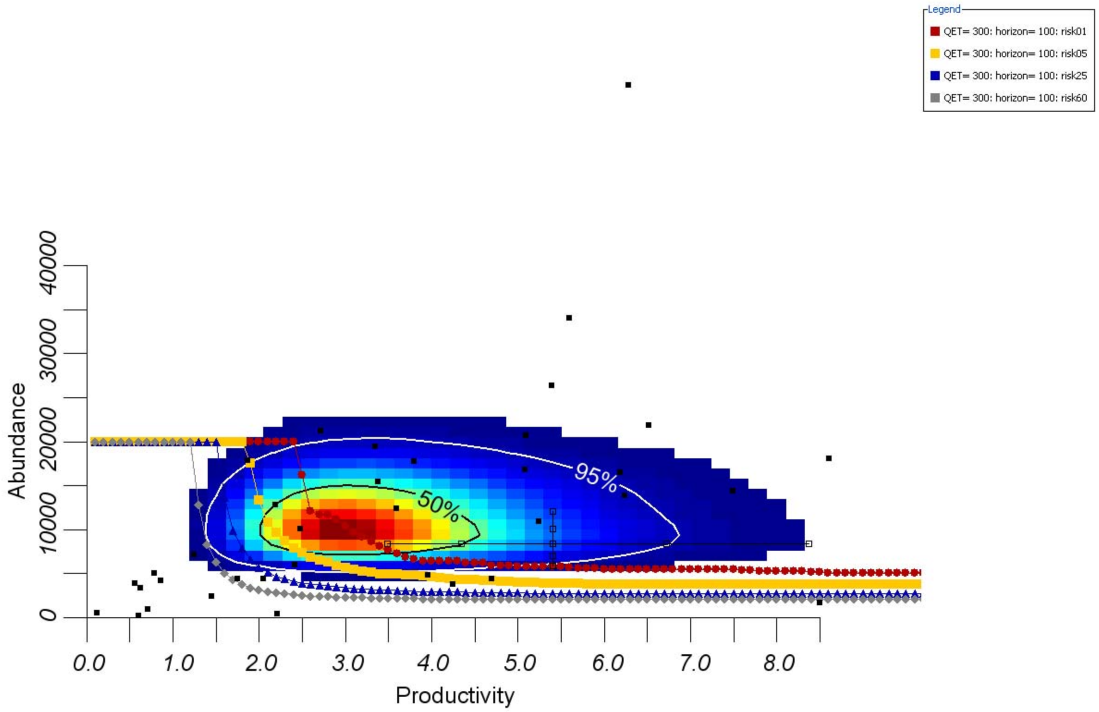


Figure 20: Clackamas River coho pre-harvest viability curve cropped to show details (graph does not include all original data points).

Table 1: Clackamas River coho summary statistics. The 95% confidence intervals are shown in parentheses.

Statistic	Escapement		Pre-harvest	
	Total Series	Recent Years	Total Series	Recent Years
Time Series Period	1957-2005	1990-2005	1957-2005	1990-2005
Length of Time Series	49	16	49	16
Geometric Mean Natural Origin Spawner Abundance	1693 (1302-2202)	1,368 (696-2,688)	NA	NA
Geometric Mean Recruit Abundance	1785 (1362-2339)	1164 (527-2574)	8448 (5830-12244)	1937 (949-3955)
Lambda	0.913 (0.821-1.014)	0.886 (0.524-1.499)	1.513 (1.231-1.859)	0.988 (0.614-1.589)
Trend in Log Abundance	1.0 (0.981-1.018)	1.017 (0.874-1.183)	NA	NA
Geometric Mean Recruits per Spawner (all broods)	0.778 (0.592-1.021)	0.718 (0.378-1.572)	3.681 (2.652-5.108)	1.195 (0.58-2.463)
Geometric Mean Recruits per Spawner (broods < median spawner abundance)	1.149 (0.77-1.713)	1.289 (0.549-3.043)	5.186 (3.315-8.112)	2.223 (0.756-6.54)
Average Hatchery Fraction	0.269	0.252	NA	NA
Average Harvest Rate	0.728	0.460	NA	NA
CAPM median extinction risk probability (5^{th}-95^{th} percentiles)	NA	NA	0.000 (0.000-0.115)	NA
PopCycle extinction risk	NA	NA	0.03	NA

Table 2: Escapement recruitment parameter estimates and relative AIC values for Clackamas River coho. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.94 (0.81-1.15)	15.6
Random walk with trend	0.78 (0.63-1)	NA	0.91 (0.79-1.13)	14.2
Constant recruitment	NA	1783 (1452-2286)	0.9 (0.78-1.12)	13.4
Beverton-Holt	2.26 (1.27-6.84)	3210 (2139-6222)	0.76 (0.67-0.96)	0
Ricker	1.47 (0.98-2.06)	2771 (2339-5249)	0.78 (0.69-0.99)	2
Hockey-stick	1.32 (1.01-5.08)	2364 (1703-3124)	0.79 (0.7-1)	3.3
MeanRS	1.15 (0.85-1.57)	1785 (1428-2211)	0.64 (0.4-0.88)	14.5

Table 3: Pre-harvest recruitment parameter estimates and relative AIC values for Clackamas River coho. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (pre-harvest relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.7 (1.47-2.08)	44
Random walk with trend	3.68 (2.86-4.98)	NA	1.09 (0.95-1.36)	5.2
Constant recruitment	NA	8457 (6387-12028)	1.24 (1.08-1.54)	16.6
Beverton-Holt	7.23 (5.51-16.86)	21530 (11889-24206)	1.02 (0.9-1.28)	1.2
Ricker	6.11 (4.14-9.65)	14383 (11330-23408)	1.03 (0.9-1.29)	1.5
Hockey-stick	5.88 (4.05-11.25)	11650 (8833-18311)	1.01 (0.89-1.28)	0
MeanRS	5.19 (3.67-7.29)	8448 (6175-11298)	1.05 (0.62-1.48)	3.1

Table 4: Clackamas River coho CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in 'extirpated or nearly so' category	0.001	0.999	1.000
Probability the population is above 'Moderate risk of extinction' category	0.000	0.987	0.995
Probability the population is above 'Viable' category	0.000	0.922	0.863
Probability the population is above 'Very low risk of extinction' category	0.000	0.692	0.637

A&P – Sandy River

A time series of abundance sufficient for quantitative analysis is available for the Sandy population (Appendix B). Descriptive graphs and viability analysis results are provided in Figure 21 to Figure 29 and in Table 5 to Table 8. The population long-term geometric mean is about 650 natural origin spawners, which is in the 'extirpated or nearly so' minimum abundance threshold category (Table 5). (Note: Coho have the highest minimum abundance thresholds because of high variability and a discrete age structure that does not provide temporal buffering of risk.) Because coho have discrete three year generations, it is useful to look at the abundance patterns for individual cohorts (Figure 22). The data show that cohort A (ending in 2005) is likely at greater risk than the other two cohorts because it has a lower average abundance. The pre-harvest viability curve analysis suggests that the population is most likely in the high risk category. The CAPM and PopCycle modeling both suggest that the population is most likely in the moderate risk category. The escapement viability curve suggests that if the population continued to experience the pattern of harvest that occurred over the available time series (average harvest rates = 71%), it would be in the 'extirpated or nearly so' risk category. The Oregon Native Fish Status report (ODFW 2005) listed the Sandy coho population as a "pass" for abundance and a "pass" for productivity.

Taken together, the data suggest the population is most likely in the high risk category for the abundance and productivity criterion.

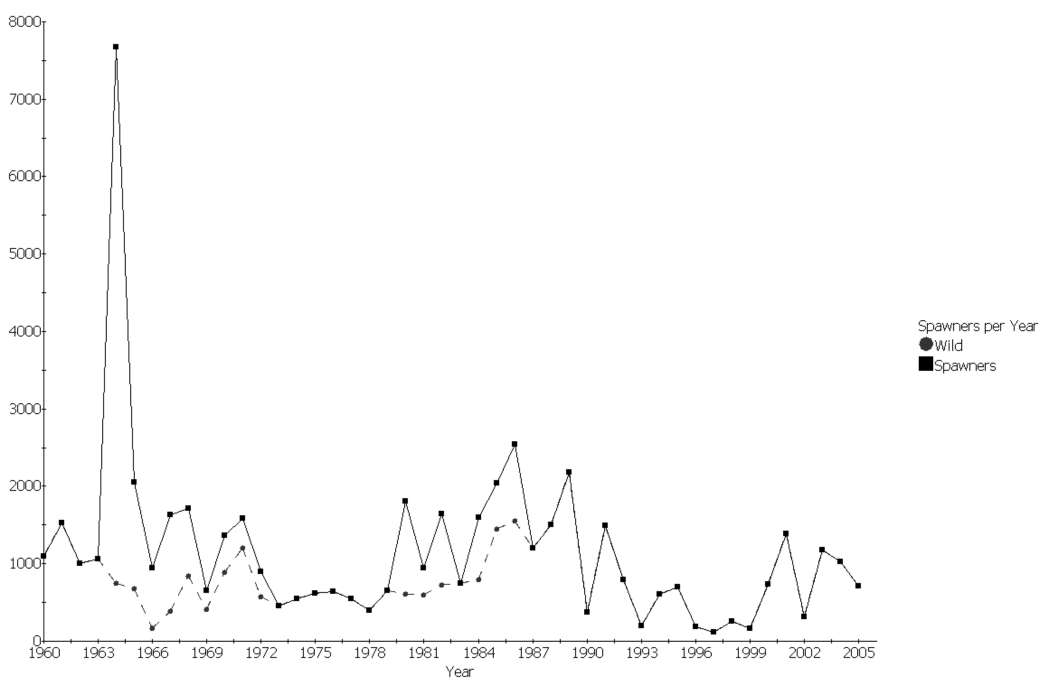
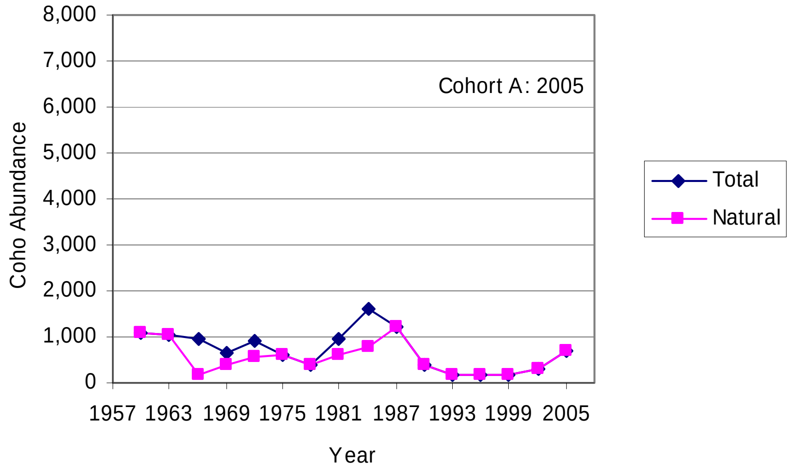
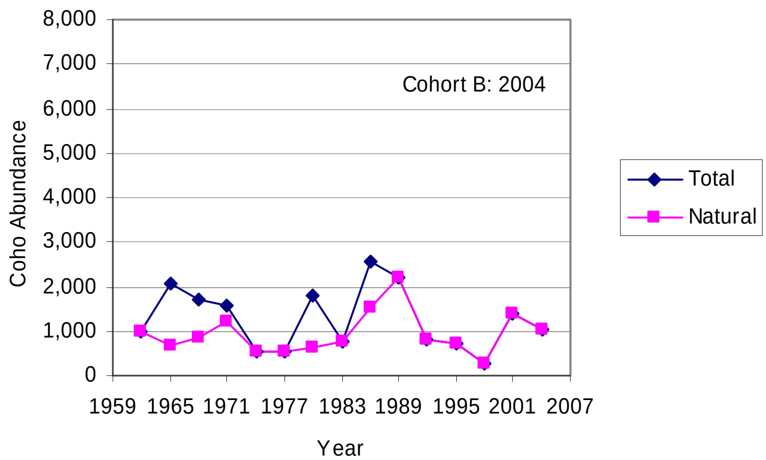


Figure 21: Sandy River coho salmon abundance at Marmot Dam.





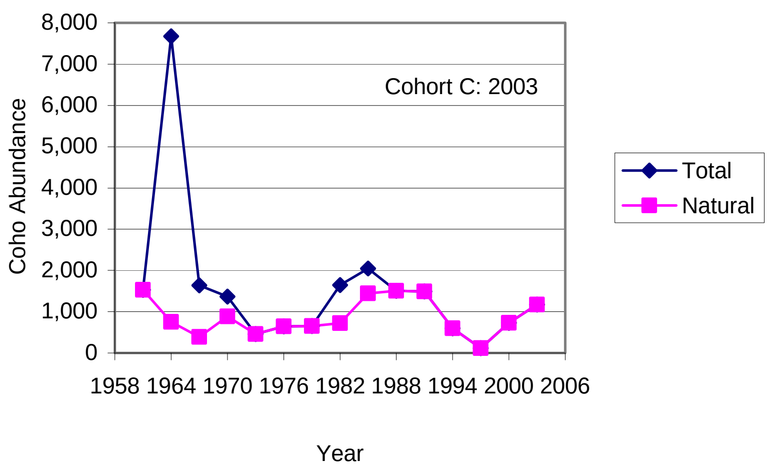


Figure 22: Sandy River coho abundance by cohort. The geometric mean natural origin abundance for cohort A is 451; for cohort B it is 738; and for cohort C it is 833.

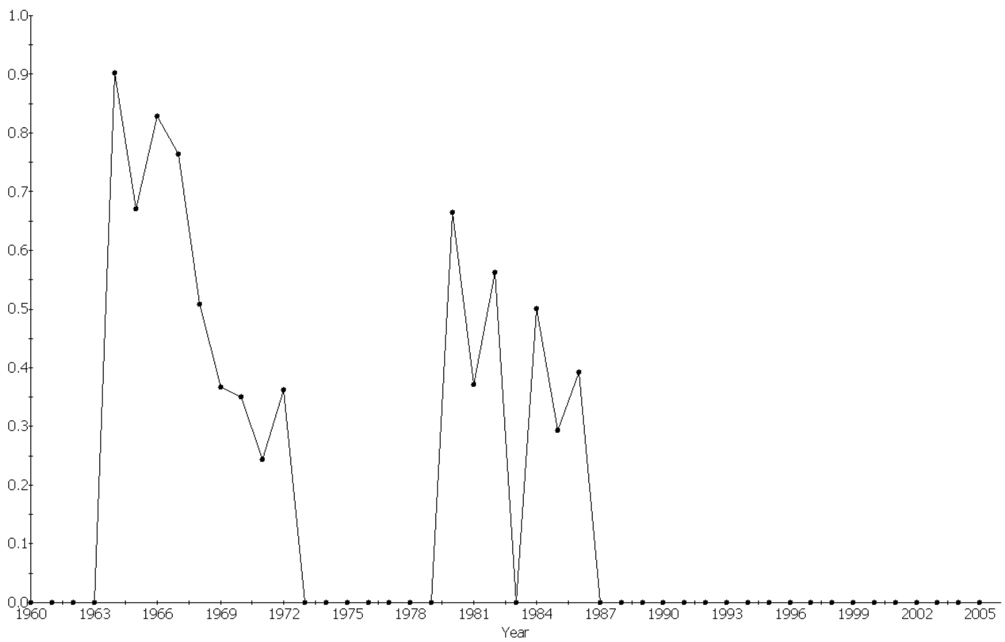


Figure 23: Sandy River coho salmon hatchery fraction.

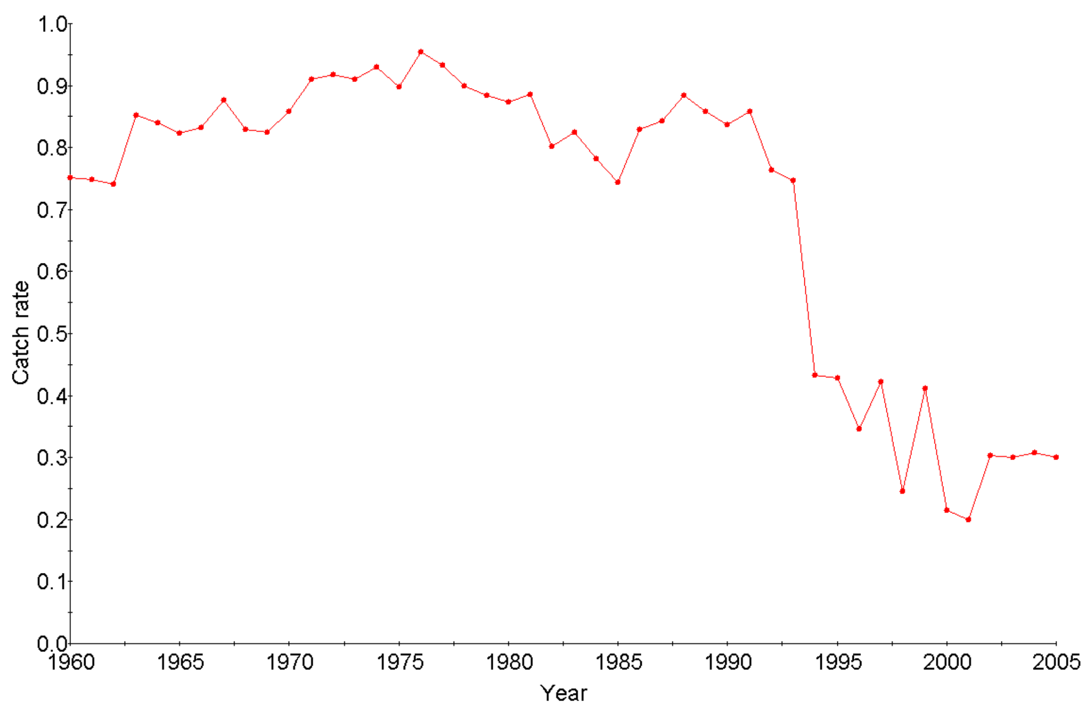


Figure 24: Sandy River coho salmon harvest rate.

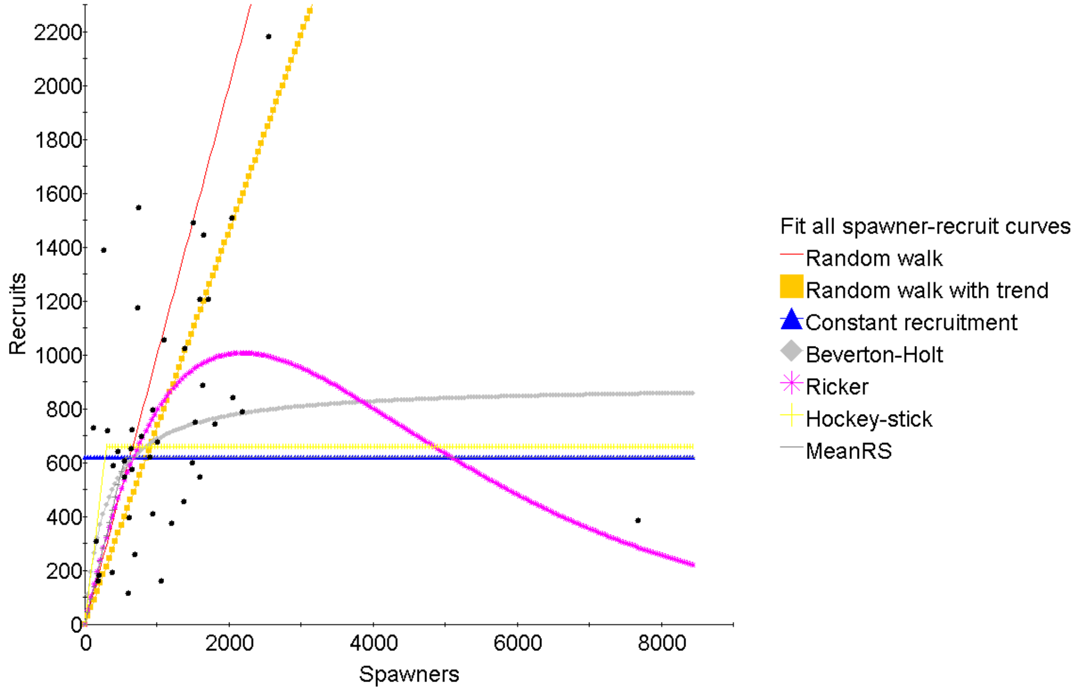


Figure 25: Sandy River coho salmon pre-harvest recruitment functions.

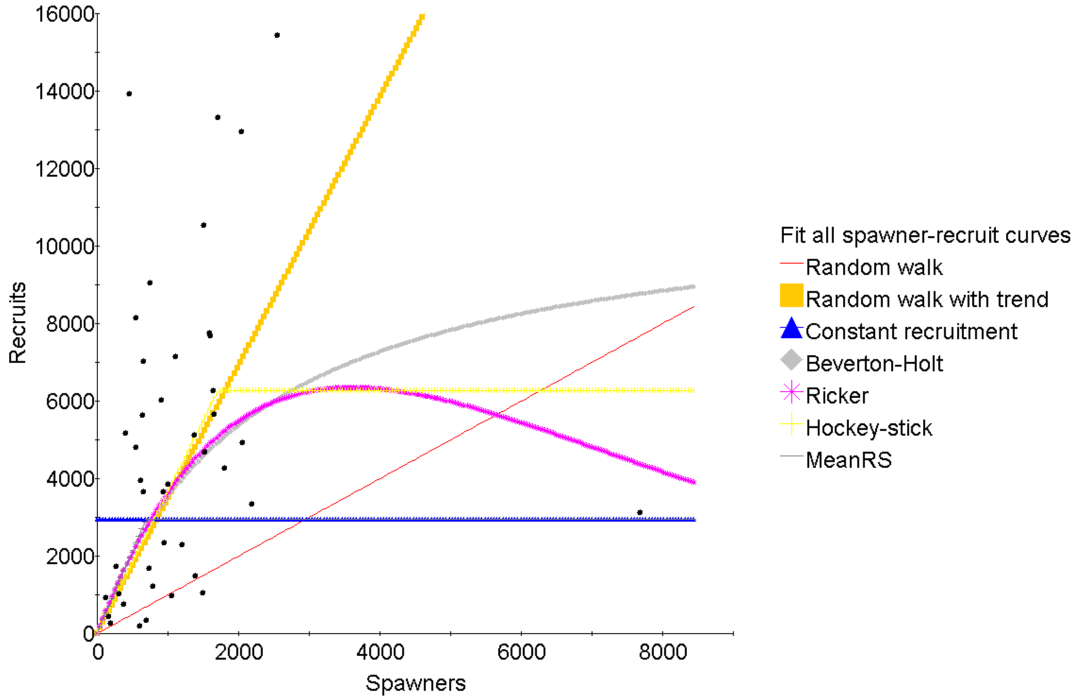


Figure 26: Sandy River coho salmon pre-harvest recruitment functions.

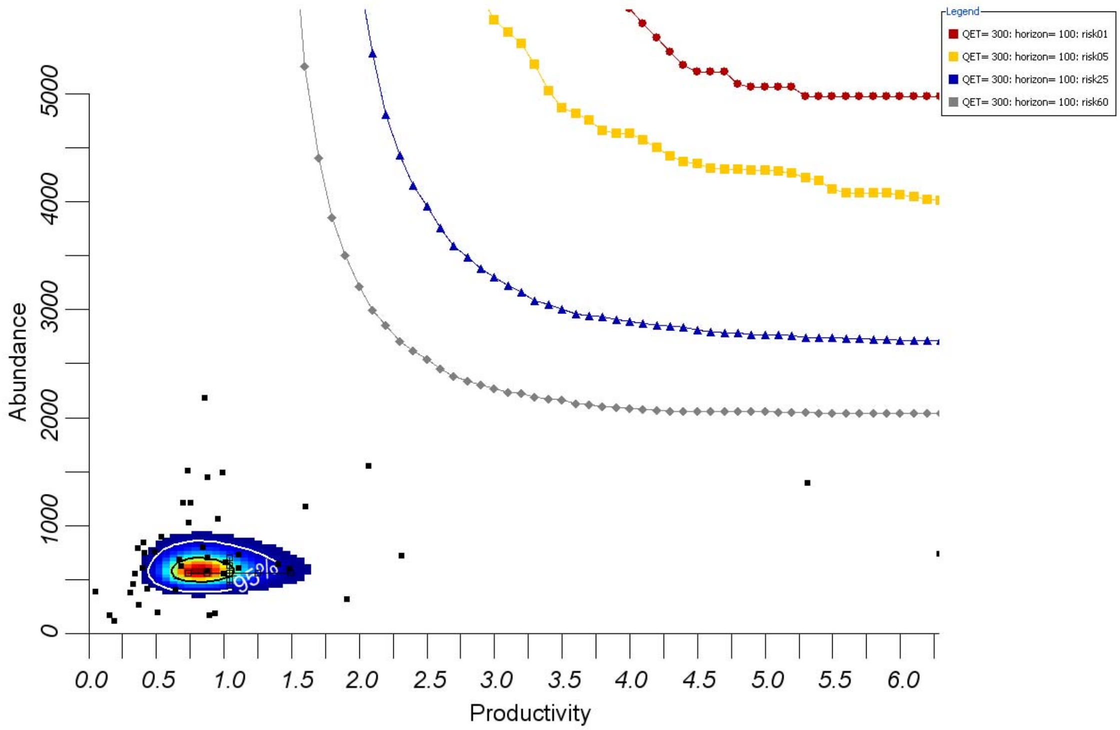


Figure 27: Sandy River coho salmon escapement viability curve.

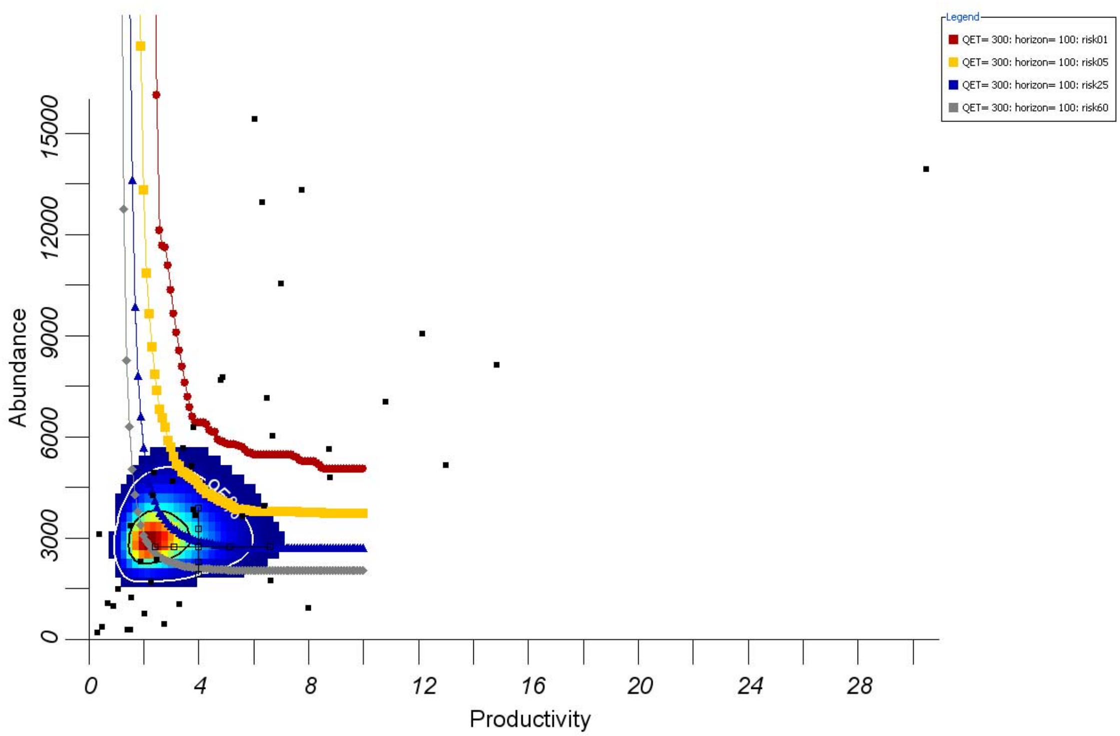


Figure 28: Sandy River coho salmon pre-harvest viability curve showing all data points.

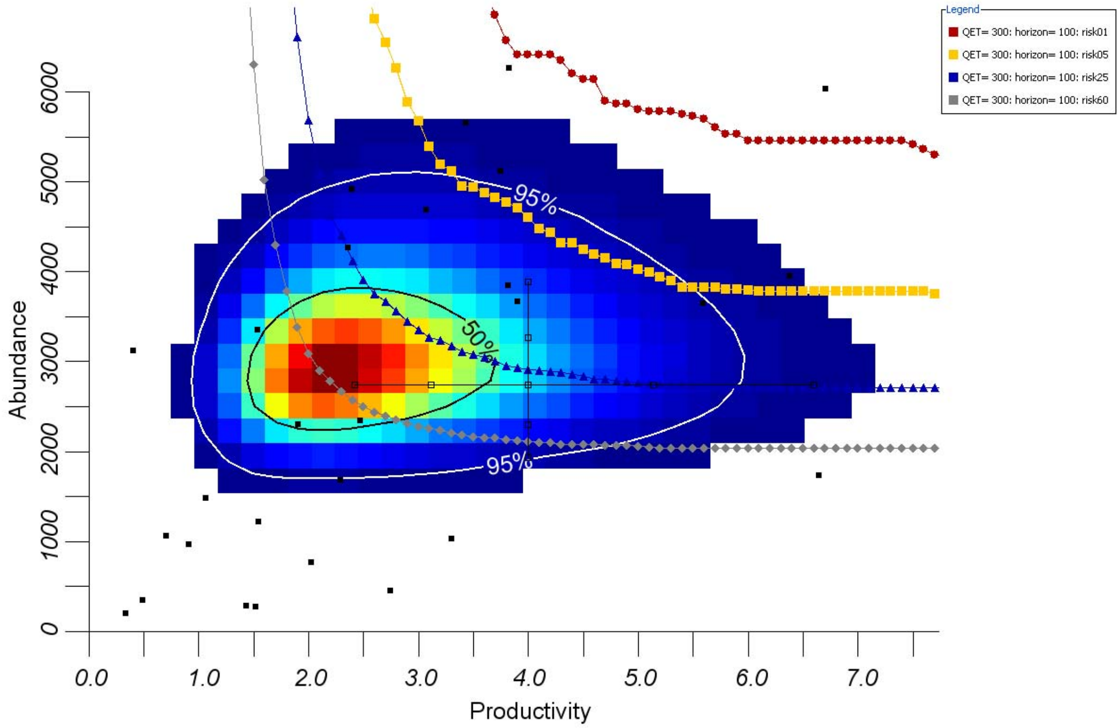


Figure 29: Sandy River coho pre-harvest viability curve cropped to show detail. (Not all the original data are shown.)

Table 5: Sandy Coho summary statistics. The 95% confidence intervals are shown in parentheses.

	Escapement		**Pre-harvest**	
Statistic	**Total Series**	**Recent Years**	**Total Series**	**Recent Years**
Time Series Period	1960-2005	1990-2005	1960-2005	1990 – 2005
Length of Time Series	46	16	46	16
Geometric Mean Natural Origin Spawner Abundance	647 (529-790)	482 (311-748)	647 (529-790)	482 (311-748)
Geometric Mean Recruit Abundance	620 (504-763)	434 (262-721)	2939 (2062-4189)	699 (443-1104)
Lambda	0.884 (0.753-1.038)	1.01 (0.547-1.865)	1.487 (1.176-1.88)	1.122 (0.607-2.072)
Trend in Log Abundance	0.993 (0.977-1.008)	1.029 (0.934-1.134)	0.993 (0.977-1.008)	1.029 (0.934-1.134)
Geometric Mean Recruits per Spawner (all broods)	0.729 (0.562-0.948)	1.053 (0.567-1.953)	3.458 (2.548-4.694)	1.695 (0.97-2.963)
Geometric Mean Recruits per Spawner (broods < median spawner abundance)	1.118 (0.793-1.577)	1.369 (0.512-3.658)	4.259 (2.593-6.995)	2.274 (0.987-5.239)
Average Hatchery Fraction	0.169	0.000	0.169	0.000
Average Harvest Rate	0.710	0.445	0.710	0.445
CAPM median extinction risk probability (5^{th}-95^{th} percentiles)	NA	NA	0.180 (0.005 -0.520)	NA
PopCycle extinction risk	NA	NA	0.31	NA

Table 6: Escapement recruitment parameter estimates and relative AIC values for Sandy coho. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (pre-harvest relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	0.9 (0.77-1.11)	27.9
Random walk with trend	0.73 (0.6-0.93)	NA	0.84 (0.73-1.06)	24.2
Constant recruitment	NA	620 (525-750)	0.67 (0.58-0.84)	4.5
Beverton-Holt	3.02 (1.8-16.41)	890 (619-1261)	0.62 (0.55-0.79)	0
Ricker	1.25 (0.97-1.6)	1007 (849-1443)	0.64 (0.57-0.83)	3.6
Hockey-stick	2.23 (1.58-18.88)	658 (534-787)	0.65 (0.58-0.83)	3.8
MeanRS	1.12 (0.86-1.46)	620 (522-732)	0.46 (0.27-0.64)	28.7

Table 7: Pre-harvest recruitment parameter estimates and relative AIC values for Sandy coho. The 95% probability intervals on parameters are shown in parentheses. The model that is the "best" approximation (i.e., relative AIC = 0) is shown in bright green. Models that nearly indistinguishable from best (i.e., relative AIC <2) are shown in darker green. Models that are possible, but less likely, contenders as best (i.e., 2 < relative AIC < 10) are shown in yellow. Models that are very unlikely to be the best approximating model (i.e., relative AIC > 10) are not highlighted (i.e., white background).

Model	Productivity	Capacity	Variance	Relative AIC
Random walk	NA	NA	1.58 (1.36-1.96)	42.1
Random walk with trend	3.46 (2.74-4.59)	NA	0.98 (0.85-1.23)	3.1
Constant recruitment	NA	2941 (2249-4098)	1.14 (0.99-1.43)	15.8
Beverton-Holt	5.12 (3.64-9.85)	11289 (5476-23164)	0.94 (0.82-1.19)	1.2
Ricker	4.78 (3.28-6.52)	6346 (4843-22083)	0.93 (0.82-1.18)	0
Hockey-stick	3.68 (2.91-5.63)	6257 (3945-21576)	0.93 (0.82-1.19)	0.8
MeanRS	4.26 (2.89-6.19)	2939 (2199-3885)	0.96 (0.6-1.33)	6.7

Table 8: Sandy coho CAPM risk category and viability curve results.

Risk Category	Viability Curves		CAPM
	Escapement	Pre-harvest	
Probability the population is not in 'extirpated or nearly so' category	0.000	0.727	0.982
Probability the population is above 'Moderate risk of extinction' category	0.000	0.310	0.562
Probability the population is above 'Viable' category	0.000	0.028	0.180
Probability the population is above 'Very low risk of extinction' category	0.000	0.001	0.063

A&P – Lower Gorge Tributaries

The Lower Gorge coho population spans the Columbia, with a portion of the population area in Washington. In this evaluation, we will just consider the Oregon side. There is limited data for population abundance and productivity for Lower Gorge coho (on either side of the Columbia). However, these data are confounded by a very high proportion of unmarked hatchery fish present in natural spawning populations. Because data collection has been sporadic and the presence of hatchery fish can only be resolved by reading scales sampled from spawned out fish, it is difficult to confirm whether a self-sustaining natural population exists. We assume that the population is most similar to the Upper Gorge/Hood River population, except that the expected abundance is lower due to the relatively smaller amount of available spawning and rearing habitat (see spatial structure section). We consider the lower gorge population in the 'extirpated or nearly so' or 'high risk' category.

A&P – Hood River/Upper Gorge Tributaries

There are two primary sources of abundance information for the Hood River/Upper Gorge coho population, neither of which is sufficient for a quantitative time series analysis. One source of information is the coho count at Powerdale dam and river mile 4.5 on the Hood River (Olsen 2004). A time series is available for 1992 to 2004 (Figure 30) and hatchery fraction information is also available (Figure 31). The Powerdale data indicate very few natural origin spawners and a high fraction of hatchery origin fish in the population. If we assume that in 1993 there was actually one fish (rather than zero), the geometric mean for natural origin fish over the time series is estimated at 12 fish. This time series is somewhat in contrast with the stratified random survey of coho abundance conducted 2002-2004 (Suring et al. 2006) (Figure 32). Because of the large number of unmarked hatchery fish in this section of the lower Columbia River and the limited collection of scales from adults (to estimate the hatchery fraction), we have a difficult time interpreting the significance of the these results. However, it is clear that a very large number of hatchery fish stray into the both the upper and lower gorge coho habitats. At this point, we consider the Powerdale counts to be a more reliable index of the status of the population, however, a more extensive understanding of the abundance and hatchery fraction for this population is required. Based primarily on the assessment of low abundance and high hatchery fraction at Powerdale, we conclude that the population is likely in the 'extirpated or near so' or 'high risk' categories. The Oregon Native Fish Status report (ODFW 2005) listed this population as "fail" for abundance and "fail" for productivity, also based on the Powerdale index.

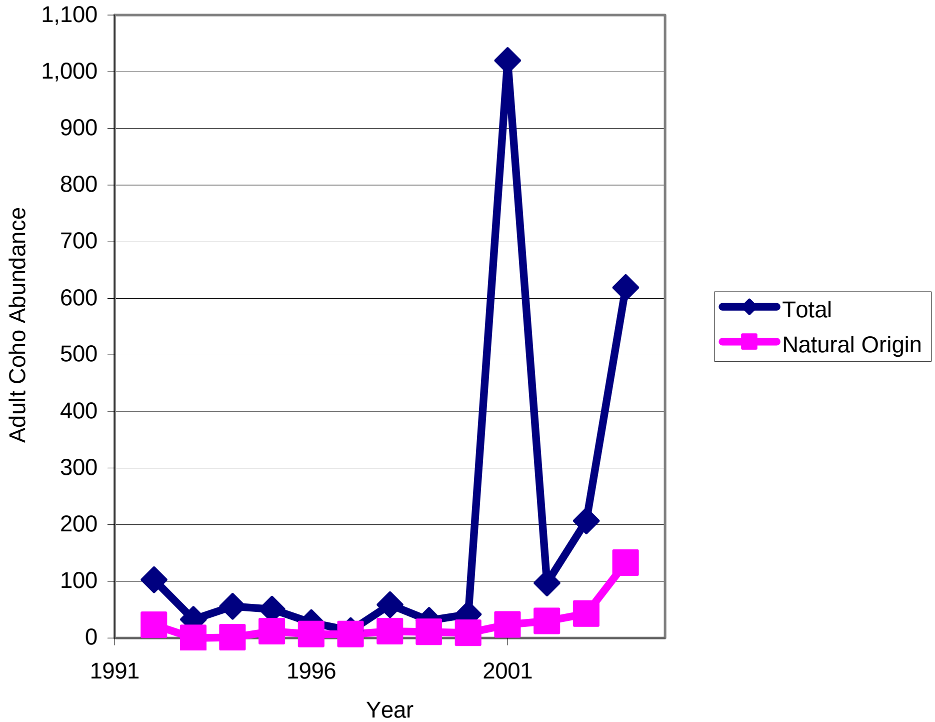


Figure 30: Counts of adult coho salmon (jacks and 3-year-old fish) at Powerdale Dam in the Hood River (Olsen 2004).

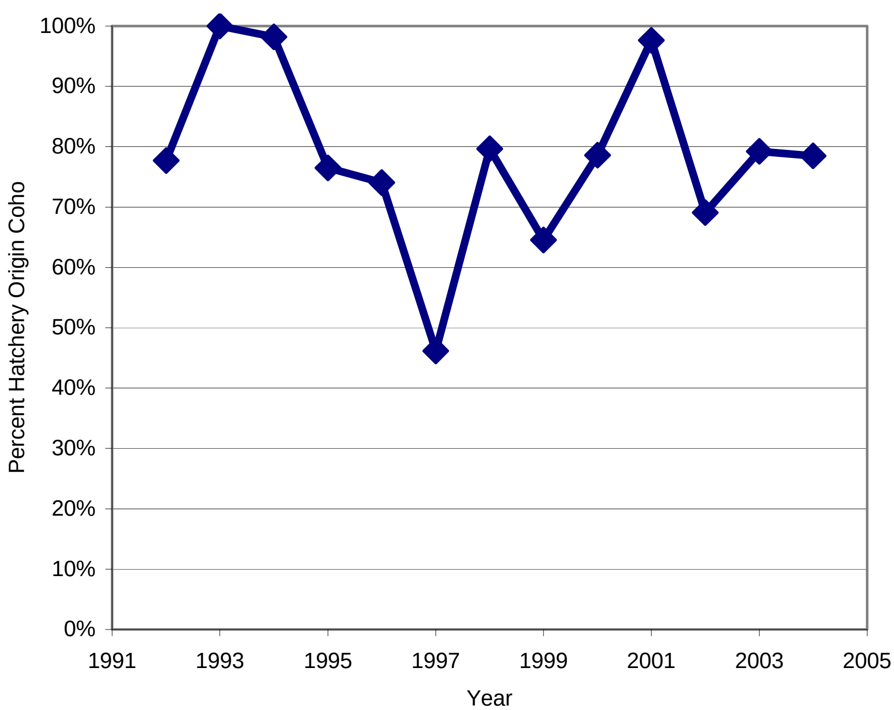


Figure 31: Fraction of hatchery origin spawners at Powerdale Dam in Hood River (Olsen 2004).

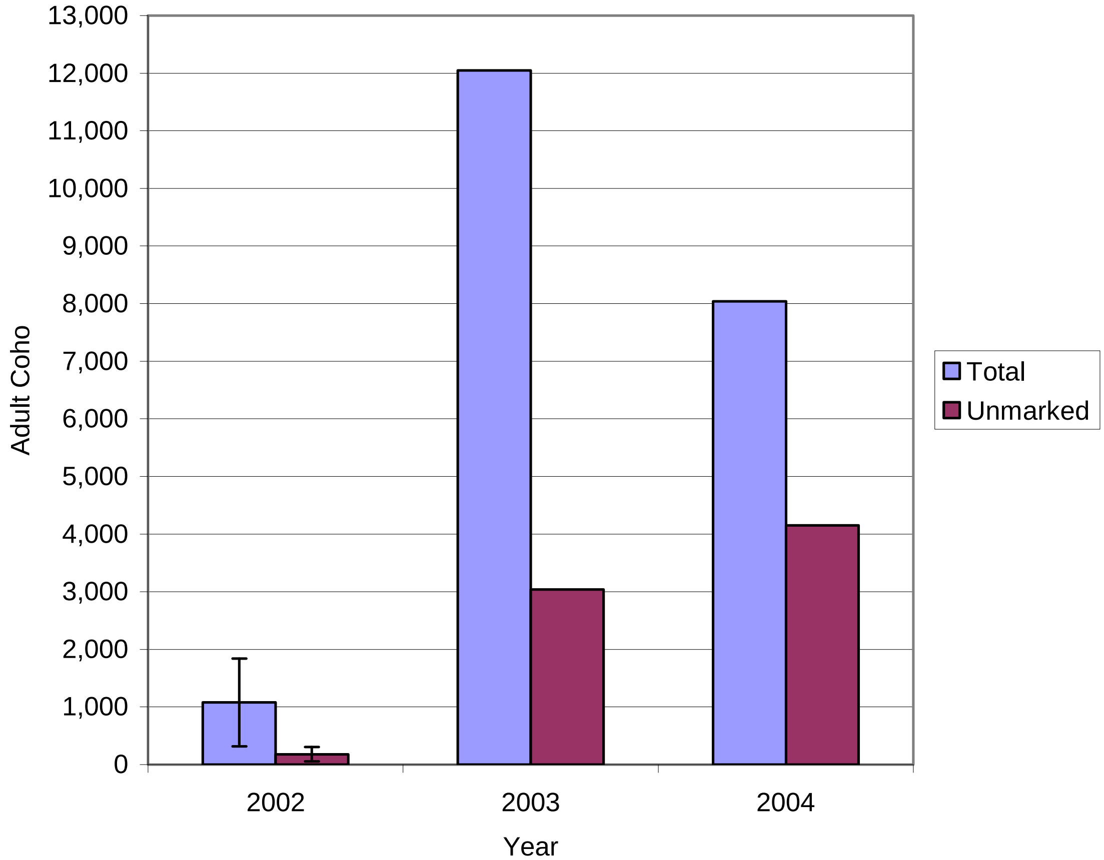


Figure 32: Abundance estimates of adult coho in Upper Gorge and Hood River population (Suring et al. 2006). The 'Total' bars show the estimated total adult coho abundance. The 'Unmarked' bars indicate potential natural origin fish. Many unmarked fish are likely of hatchery origin, so the hatchery fraction is likely even higher than suggested by this graph. The error bars are 95% confidence intervals (only available for 2002).

A&P – Criterion Summary

For the abundance and productivity criterion, the most probable risk category for most of these populations is high or very high (Figure 33). Only one population, the Clackamas, is most probably in the low risk category. The Sandy population is most likely in the high risk category, but the range of possible risk categories is from very high risk to viable. Although there is considerable uncertainty about these ‘most probable’ classifications, as reflected by the shape of the diamonds (Figure 33), under even the most optimistic interpretation no more than two of the eight populations could possibly fall into the viable classification. From the perspective of this viability criterion, LCR coho populations in Oregon are at high risk.

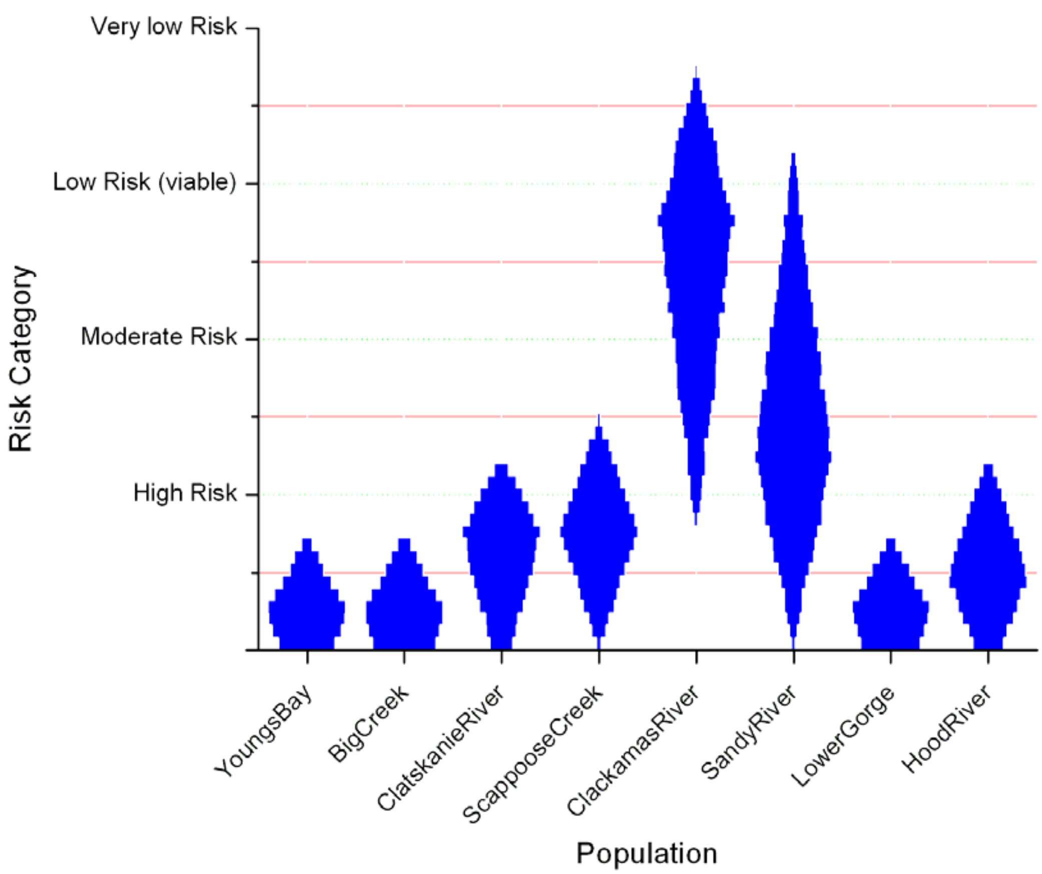


Figure 33: Lower Columbia River coho salmon risk status summary based on evaluation of abundance and productivity only.

III. Spatial Structure

SS – Youngs Bay

Youngs Bay streams including the Skipanon, Lewis and Clark, Klaskanine, and Wallooskee rivers provide an estimated 200 km of usable coho habitat (ODFW 2005) and 563 km of accessible streams (includes higher order streams) (Maher et al. 2005)(Figure 34). Most historical areas remain accessible to anadromous fish (ODFW 2005). A fish ladder provides passage at a Municipal water diversion on the upper Lewis and Clark mainstem. Coho are also trapped and released above hatchery diversion structures on the North Fork Klaskanine. Some loss of accessibility has occurred in higher order tributary streams which were not significant historical coho production areas. Spatial structure has likely been reduced by habitat degradation, particularly in valley floor habitats of the lower basin. Habitat changes in the Columbia mainstem and estuary would likely have a significant effect on coho salmon and contributed to adjustments to the spatial structure scores. Access scores were modified for effects of habitat degradation on currently accessible habitats.

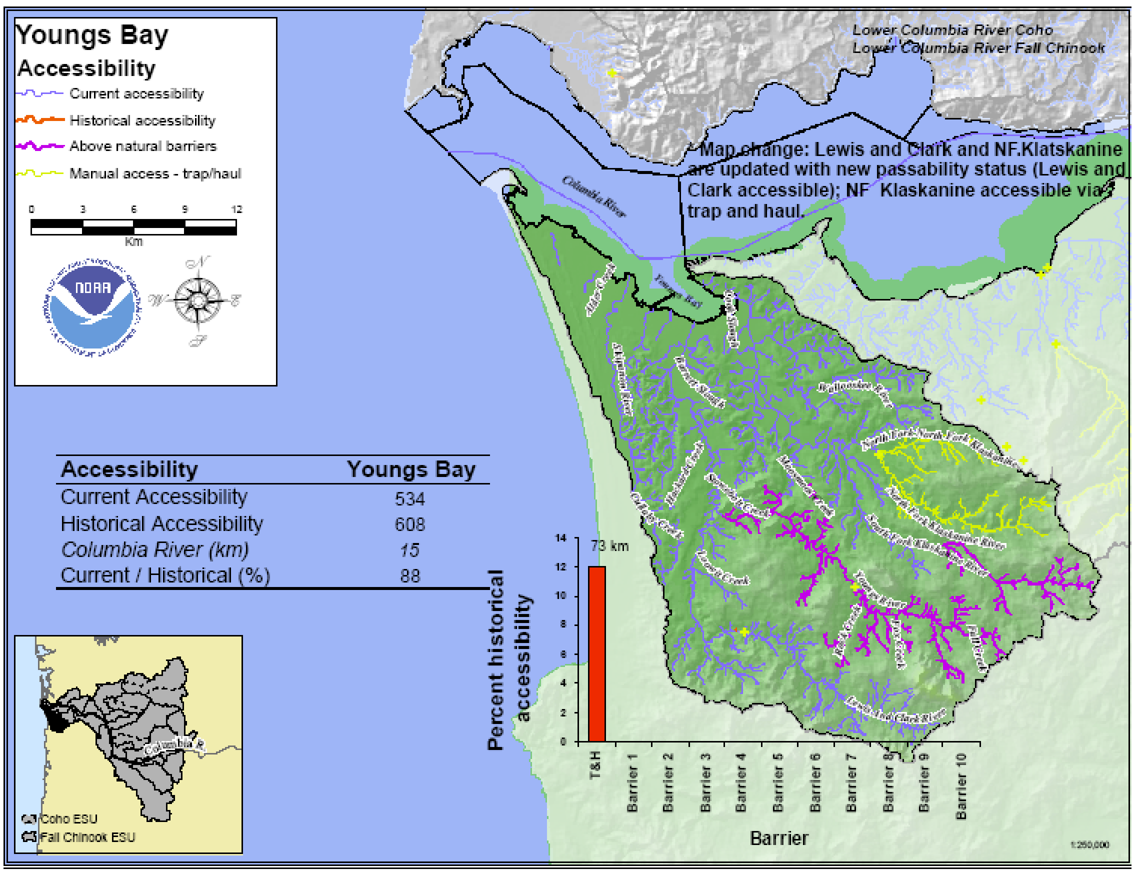


Figure 34 Youngs Bay coho salmon current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Big Creek

Big Creek subbasin streams including the John Day River, Bear Creek, Big Creek, and Gnat Creek historically provided an estimated 180 km of usable coho habitat (ODFW 2005) and historically 352 km of accessible streams (includes higher order streams) (Maher et al. 2005) (Figure 35). Most usable areas (96%) and historically accessible stream km (88%) remain accessible to anadromous fish (ODFW 2005, Maher et al 2005). Hatchery barriers previously limited access to upper Big Creek but since the 2001-2002 return year, all unmarked adult coho returns have been passed upstream of the hatchery weir to utilize the available habitat upstream. A hatchery diversion in upper Gnat Creek blocks coho passage to approximately 6 km of historical habitat but the blocked area is marginal coho habitat. Some loss of accessibility has also occurred in higher order tributary streams which were not significant historical coho production areas. Spatial structure has likely been reduced by habitat degradation, particularly in valley floor habitats of the lower basin. Habitat changes in the Columbia mainstem and estuary would likely have a significant effect on coho salmon and contributed to adjustments to the spatial structure scores. Access scores were modified for effects of habitat degradation on currently accessible habitats (-0.5).

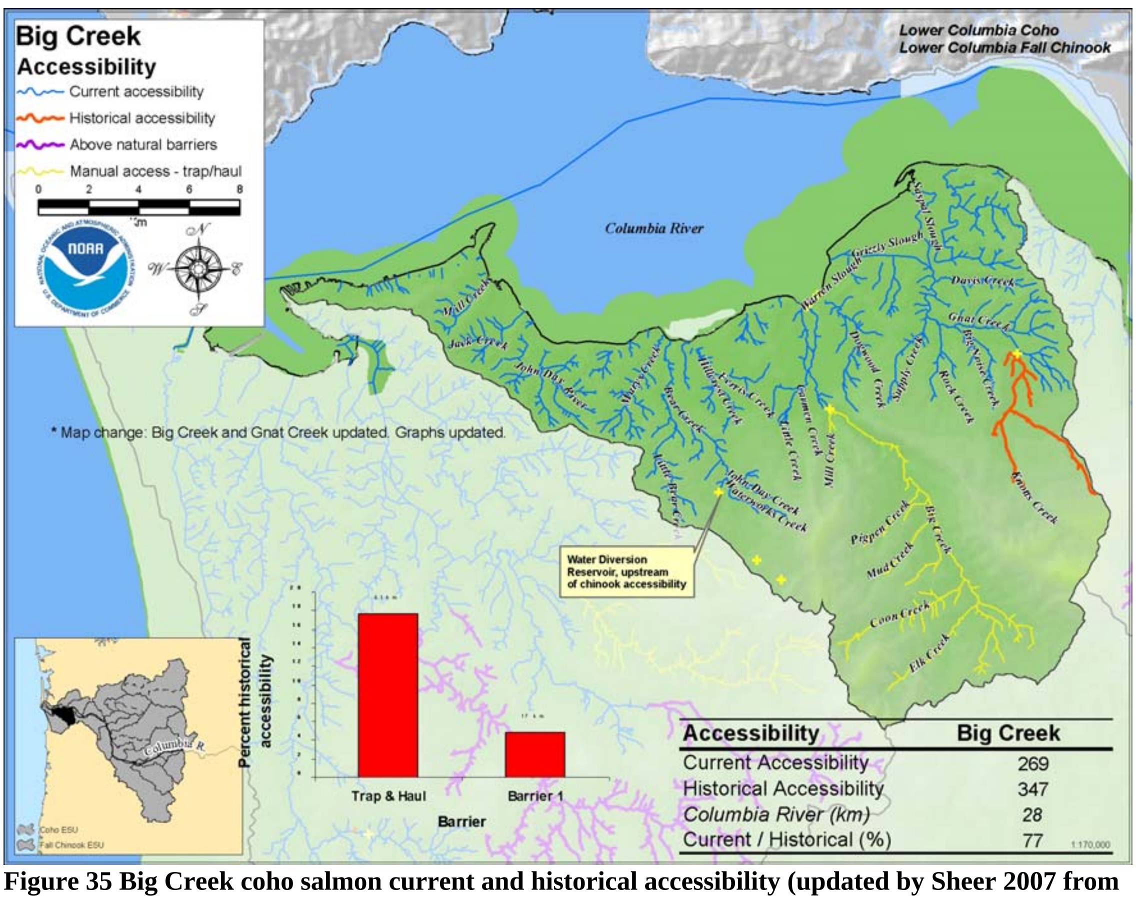
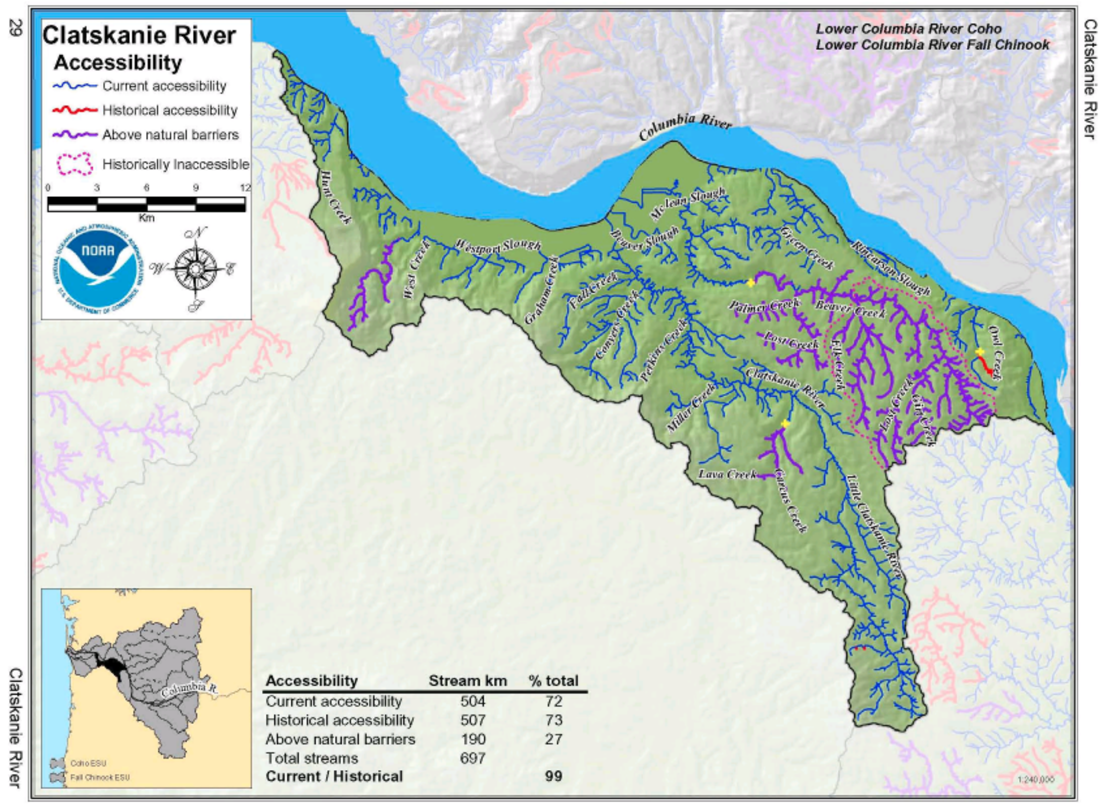


Figure 35 Big Creek coho salmon current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Clatskanie River

Clatskanie subbasin streams, including the Clatskanie River and Beaver Creek, historically provided an estimated 135 km of usable coho habitat (ODFW 2005) and 507 km of accessible streams (includes higher order streams) (Maher et al. 2005) (Figure 36). Most usable areas (92%) and accessible stream km (99%) remain accessible to anadromous fish (ODFW 2005, Maher et al. 2005). Some loss of accessibility has occurred in higher order tributary streams which were not significant historical coho production areas. Spatial structure has likely been reduced by habitat degradation, particularly in valley floor habitats of the lower basin. Habitat changes in the Columbia mainstem and estuary would likely have a significant effect on coho salmon and contributed to adjustments to the spatial structure scores. Access scores were modified for effects of habitat degradation on currently accessible habitats (-1).



Accessibility	Stream km	% total
Current accessibility	504	72
Historical accessibility	507	73
Above natural barriers	190	27
Total streams	697	
Current / Historical		**99**

Figure 36 Clatskanie River coho salmon current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Scappoose Creek

The Scappoose subbasin includes a series of small streams including Goble, Tide, Milton, and Scappoose creeks. This area historically provided an estimated 162 km of usable coho habitat (ODFW 2005) and 343 km of accessible streams (includes higher order streams) (Maher et al. 2005) (Figure 37). Most usable areas (92%) and accessible stream km (92%) remain accessible to anadromous fish (ODFW 2005, Maher et al. 2005). Some loss of accessibility has occurred in higher order tributary streams which were not significant historical coho production areas. Spatial structure has likely been reduced by habitat degradation, particularly in valley floor habitats of the lower basin. Habitat changes in the Columbia mainstem and estuary would likely have a significant effect on coho salmon and contributed to adjustments to the spatial structure scores. Access scores were modified for effects of habitat degradation on currently accessible habitats (-0.5).

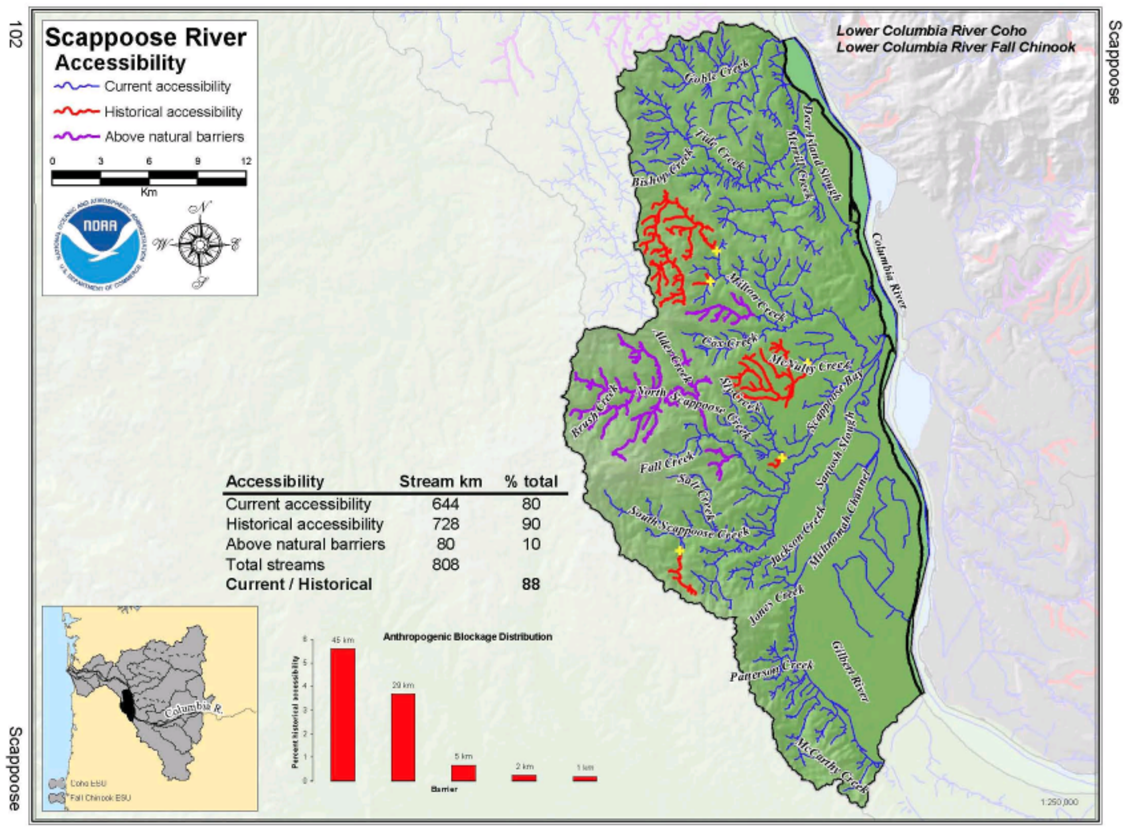


Figure 37 Scappoose Creek coho salmon current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Clackamas River

This area historically provided an estimated 385 km of usable coho habitat (ODFW 2005) and 1,884 km of accessible streams, including higher-order streams (Maher et al. 2005) (Figure 38). Virtually all usable areas (97%) and accessible stream km (96%) remain accessible to anadromous fish (ODFW 2005, Maher et al. 2005). Losses of accessibility are limited to higher order tributary streams, primarily due to watershed development in the lower basin. The upper Clackamas basin contains over half of the historically-suitable habitat for coho and most of that habitat is of high quality today. However, spatial structure has been reduced by significant habitat degradation in lower basin tributaries (e.g., Johnson and Kellogg Creeks). The watershed score was reduced (-0.5) to address a likely loss in spatial diversity related to habitat degradation in the low elevation streams.

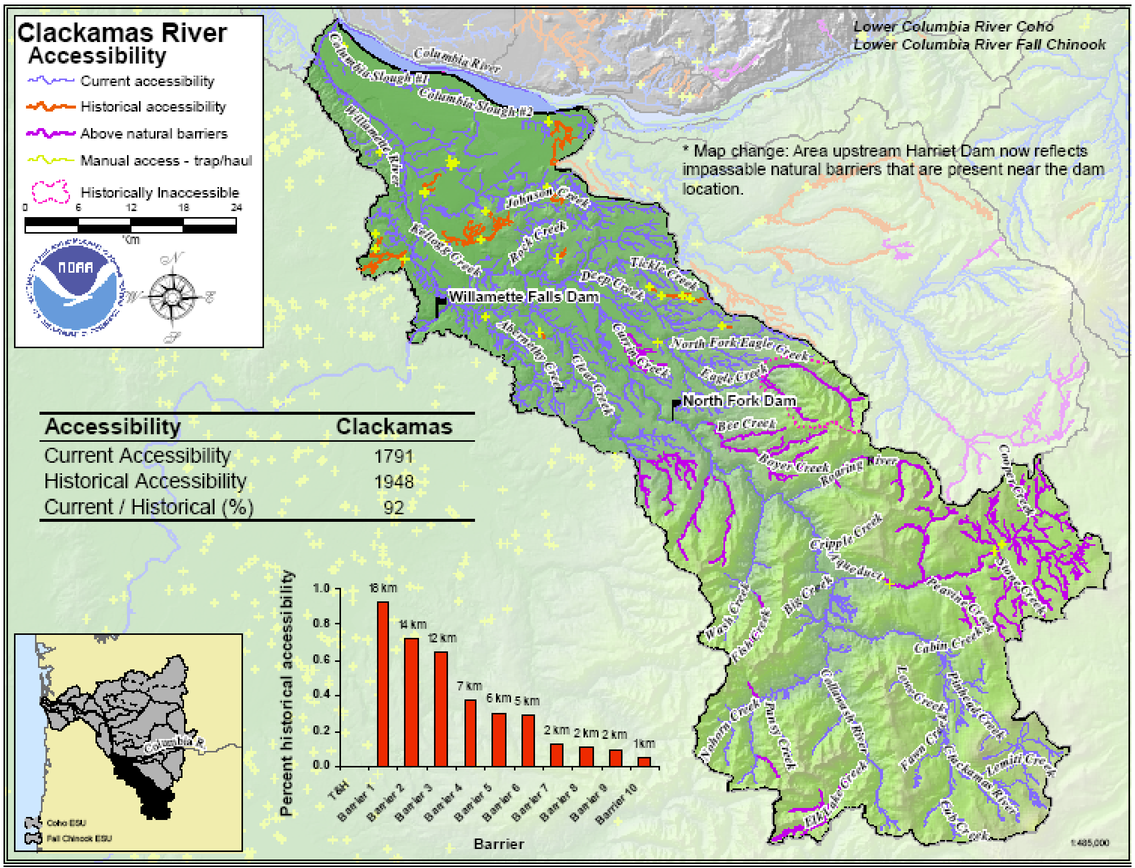


Figure 38: Clackamas coho salmon current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Sandy River

This area historically provided an estimated 264 km of usable coho habitat (ODFW 2005) and 649 km of accessible streams (includes higher order streams) (Maher et al. 2005) (Figure 39). Significant portions (10%) of the historically used coho habitat in the Sandy River have been blocked by dam construction in the Bull Run and Little Sandy watersheds (ODFW 2005). A hatchery weir on Cedar Creek also blocks passage into the upper portions of that tributary. Blocked areas were likely productive habitats for coho. In the remainder of the basin, accessible areas are represented by productive high quality habitat, particularly in the forested upper basin.

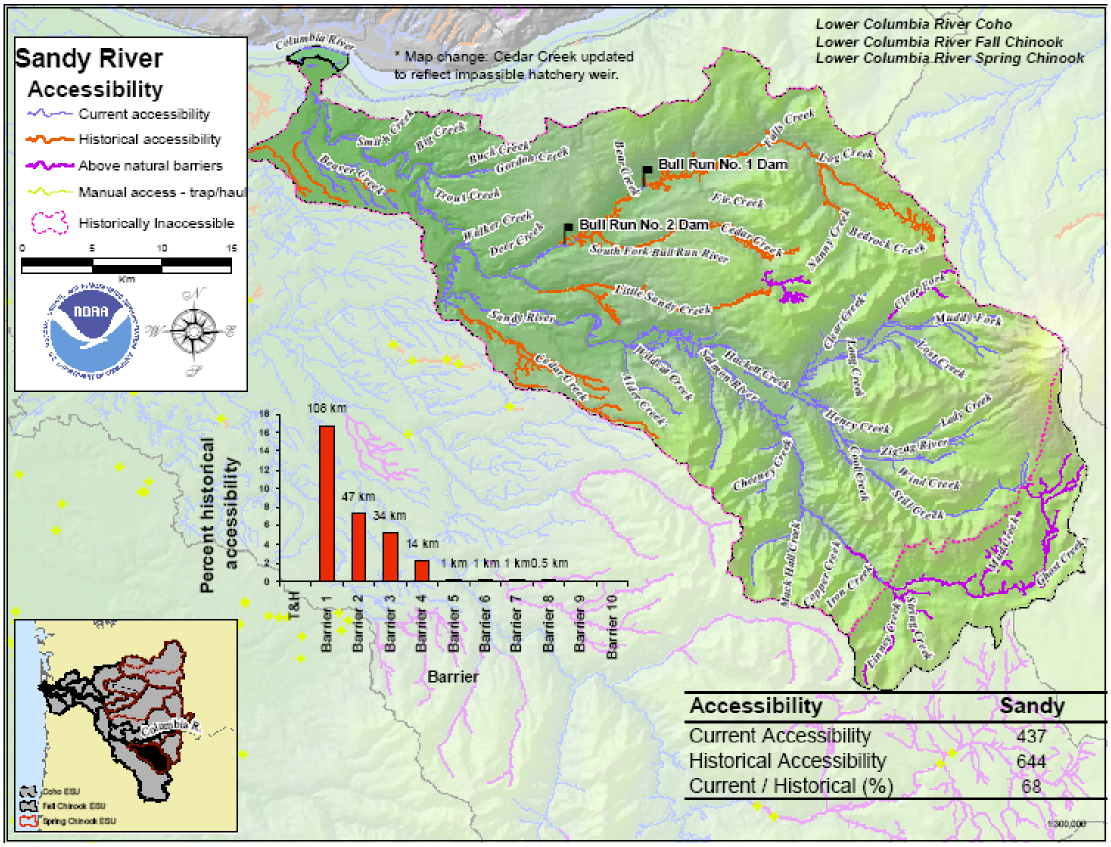


Figure 39: Sandy River coho salmon current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Lower Gorge Tributaries

Most of the small Columbia River gorge streams between the Sandy River and Eagle Creek remain largely accessible to coho (ODFW 2005) (Figure 40). Habitat availability is limited to the lower portions of these streams by topography. Hatchery weirs block coho access to small portions of Tanner and Eagle Creeks. However, because the historical total kilometers of accessible stream is also small for this population, these blockage represent a significant reduction in the percent of historical habitat. The watershed score was reduced (-0.5) to address a likely loss in spatial diversity related to habitat degradation.

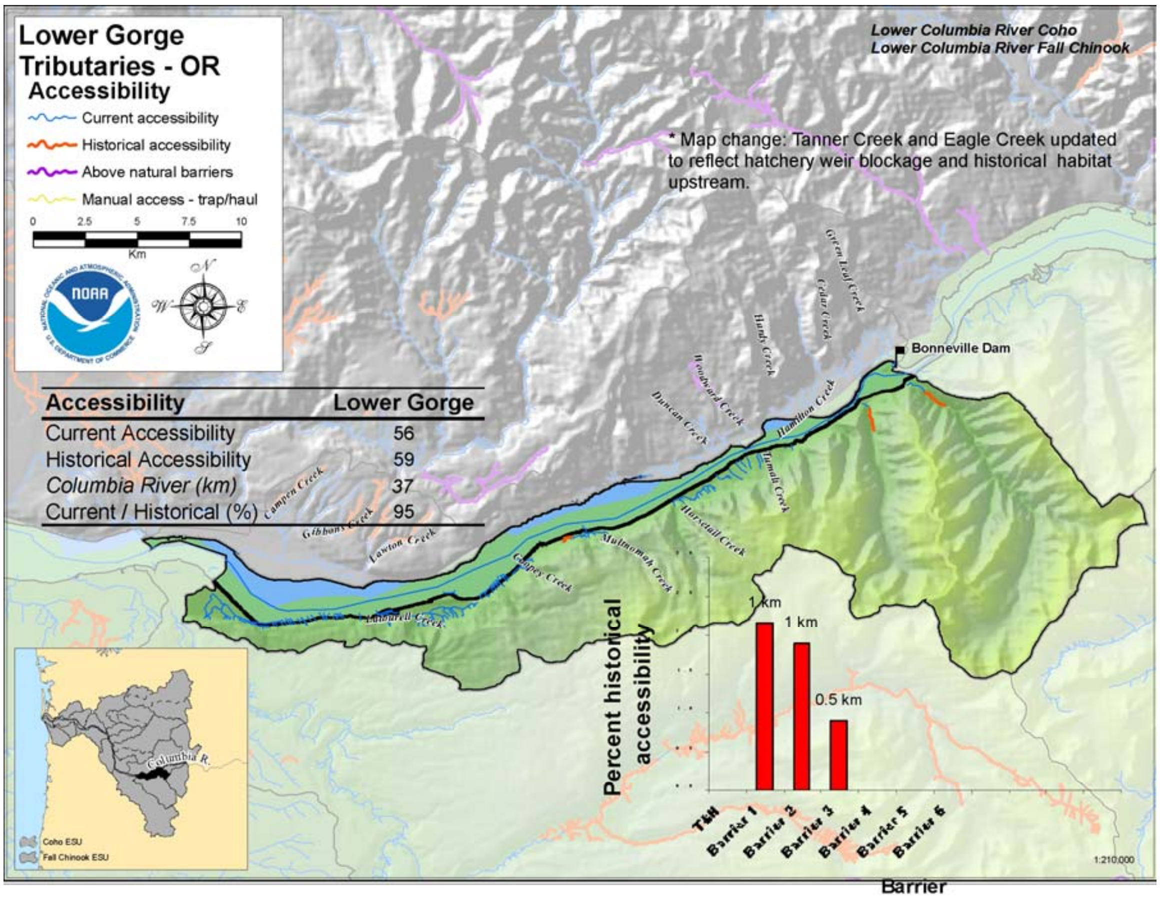


Figure 40: Lower Gorge coho salmon current and historical accessibility (updated by Sheer 2007 from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use.

SS – Hood River/Upper Gorge Tributaries

This area historically provided an estimated 130 km of usable coho habitat (ODFW 2005) and 609 km of accessible streams (includes higher order streams) (Maher et al. 2005) (Figures 41 and 42). Virtually all usable areas (97%) and accessible stream km (99%) remain accessible to anadromous fish (ODFW 2005, Maher et al. 2005). Blockages are limited to only a few headwater reaches and these streams do not represent significant historical coho production areas. Declines in habitat quality in lower elevations streams of the basin have likely reduced the spatial structure of coho production in the basin. The small Columbia River gorge streams upstream from Eagle Creek remain largely accessible to coho. The amount of habitat is limited to the lower portions of these streams by topography and portions of the lower reaches have been inundated by the Bonneville Dam reservoir. Other local habitat alternations and development have likely reduced habitat quality in some streams. The limited distribution of coho in the basin warrants a downward adjustment to the spatial score. (-1)

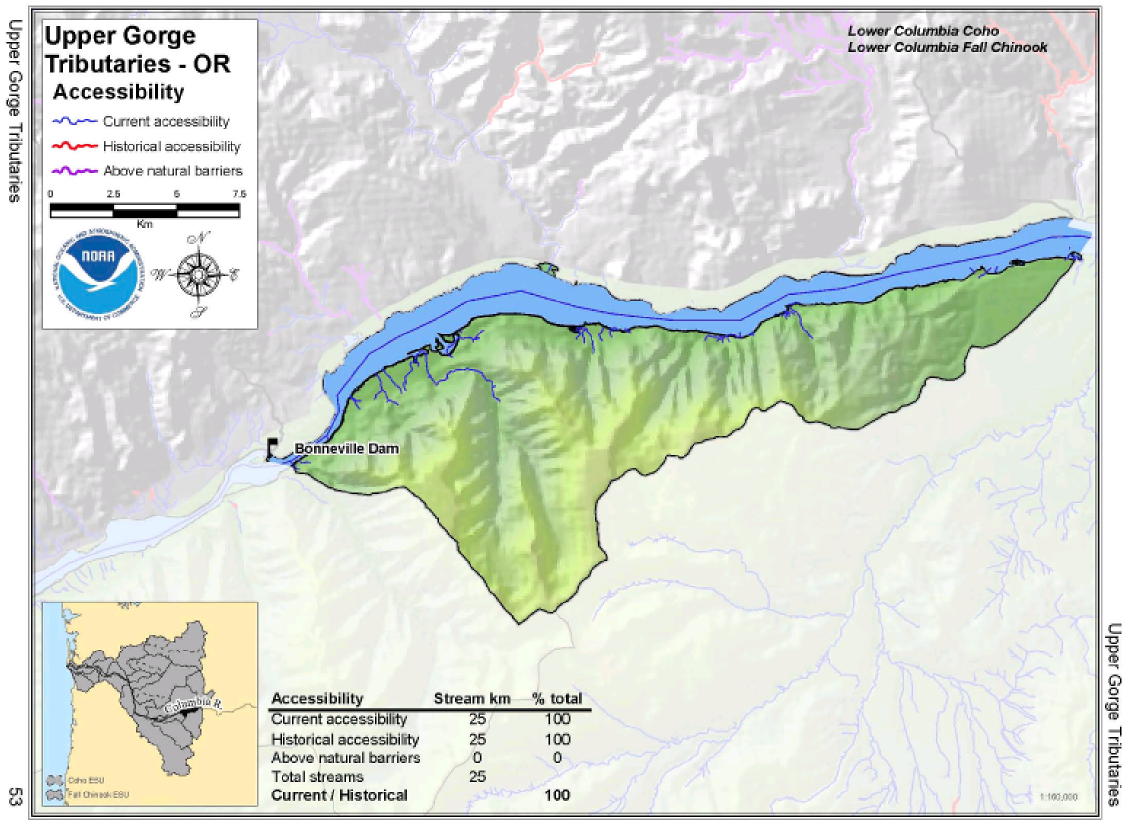


Figure 41 Upper Gorge coho salmon current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use. The Upper Gorge area and Hood River are combined into a single coho salmon population.

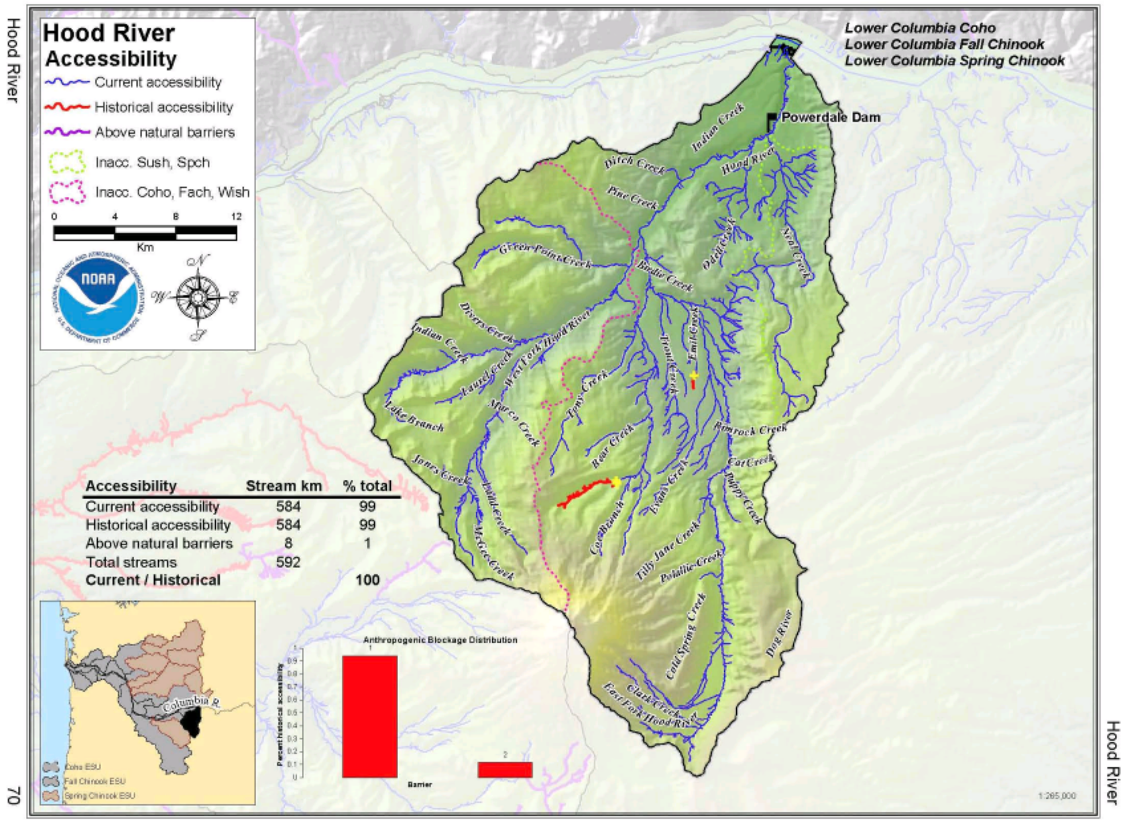


Figure 42 Hood River coho salmon current and historical accessibility (from Maher et al. 2005). As described in the Introduction (Section 1), these graphs depict *access* (i.e., where fish could swim) and not necessarily habitat that fish would use. The Upper Gorge area and Hood River are combined into a single coho population.

SS – Criterion Summary

The Sandy River has experienced more than 30 % loss of habitat historically assessable to coho due to anthropogenic blockages and Big Creek and Scappoose Creeks have experienced more than 10% loss (Figure 43). For the other basins, the percent loss has been less than 5%. SS scores for each population were adjusted, where applicable, on the basis of two factors: 1) the suitability/quality of the blocked habitat with respect to coho production and 2) the degree to which the remaining accessible habitat has been degraded from historical conditions. The adjustments and final SS scores for each population are presented in Table 9. Additional details on SS scoring methodology used are provided in Section 1 of this report.

The net assessment of the spatial structure criterion for each population is represented by the diamonds in Figure 44. As described in Section 1 of this report, these diamonds were constructed on the basis of the most likely high, low and mode score for each criterion. The mode score (widest portion of the diamonds in Figure 44) corresponds with the SS rating for each population (Table 9). High and low values (corresponding with the tops and bottoms of the diamonds in Figure 44) were subjectively determined on the basis that the confidence in the accuracy of the SS rating was low for all populations (Table 9). Because of this low confidence, the upper and lower bounds on the SS rating represented a possible score interval that was relatively large. As a result, while the widest portion of the diamonds were at or greater than threshold for low risk category for most of the populations, the lower portion of all the diamonds extended downward into the moderate risk, (non-viable) category.

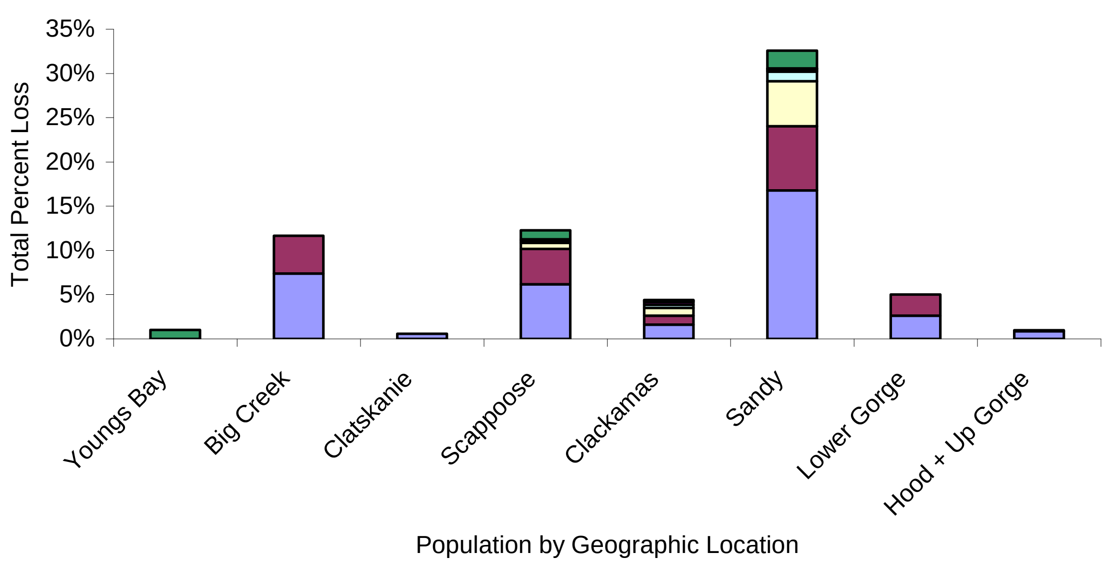


Figure 43: Summary of percent loss in access due to anthropogenic blockages (based on Maher et al. 2004). The total height of the bar indicates total loss. The individual colors represent amount lost by individual blockages. The individual blockages are stacked from largest on the bottom to smallest on the top. These percentage estimates are based on most recent (2007) barrier information that differs from the Maher et al. figures as described in the accessibility map figure legends.

Table 9: Spatial structure persistence category scores for LCR coho populations.

Population	Base Access Score	Adjustment for Large Single Blockage	Adjusted Access Score	SS Rating Considering: Access Score, Historical Use Distribution, and Habitat Degradation	Confidence in SS rating
Youngs Bay	4	No	4	3	Low
Big Creek	3	No	3	2.5	Low
Clatskanie	4	No	4	3	Low
Scappoose	3	No	3	2.5	Low
Clackamas	4	No	3	3	Low
Sandy	2	Yes	1.5	1.5	Low
Lower Gorge Tributaries	3	No	3	2.5	Low
Hood River	4	No	4	3	Low

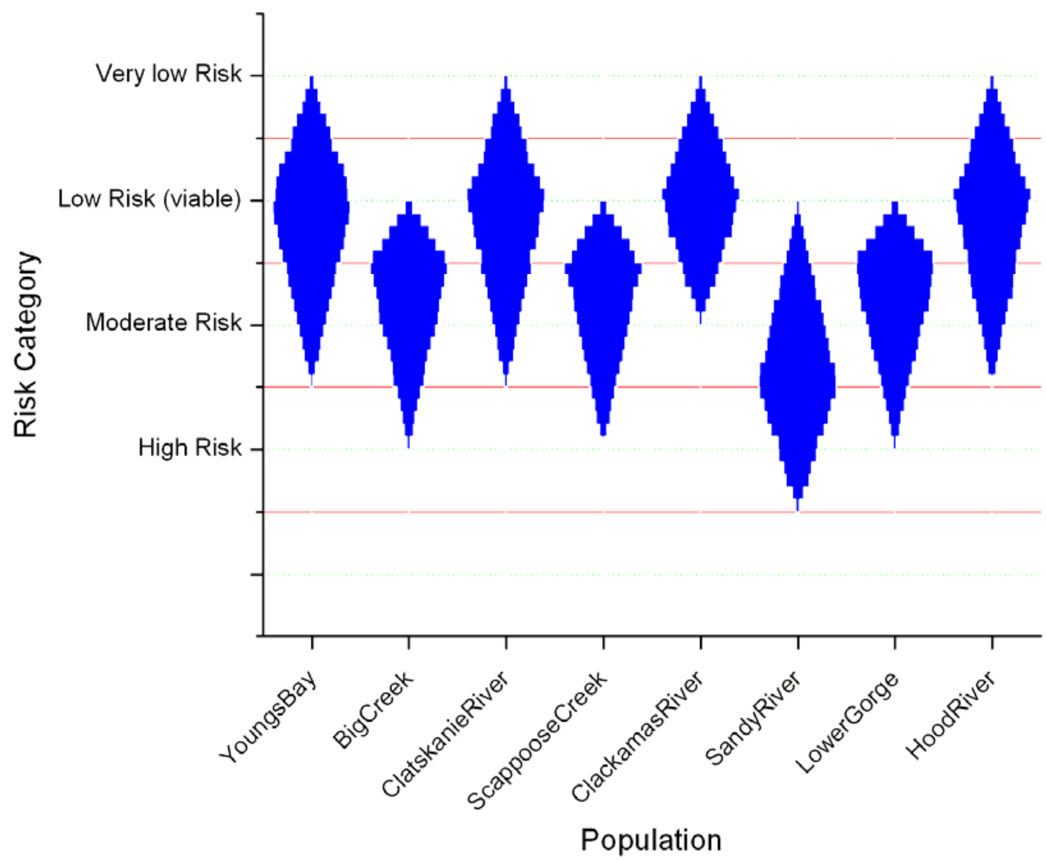


Figure 44 Lower Columbia River coho salmon risk status summary based on the evaluation of spatial structure only.

IV. Diversity Overview

Coho salmon in the Lower Columbia River ESU display one of two major life history types. Early returning, or Type S (for south turning), coho salmon return to freshwater from August to October and spawn from October to November. Coded-wire tagged Type S hatchery fish are predominately recovered off of the Oregon Coast, to the south of the Columbia River, approximately 40% of recoveries (Weitkamp et al. 1995, Weitkamp et al. 2001). The other life history type, late-returning or Type N (north turning) coho salmon, return to freshwater from October through November or December and spawn primarily from November through February, with some fish spawning through to March (WDF et al. 1951). Type N coho salmon have an ocean migration that is predominately north of the mouth of the Columbia River. Differences in ocean migration have been the focus of management strategies to provide fisheries opportunities for certain coastal areas. Ecologically, the run-timing associated with each of these run types is probably more important. It is thought that early returning coho salmon migrate to headwater areas and late-returning fish migrate to the reaches of larger rivers or into smaller stream streams and creeks along the Columbia River (analogous to spring and fall-run chinook salmon). Additionally, coho salmon historically migrating to areas above Bonneville Dam were thought to be early run fish. There does not appear to be much variation in age at emigration to the ocean or in age at maturation. Columbia River coho salmon smolt during their second spring and return to freshwater after one or two years in the ocean. One ocean fish are predominately males (jacks). Analysis of coho salmon scales from adults captured in the Columbia River fishery in 1914, also revealed the presence of two-year old smolts (Marr 1943), although these were thought to have originated from rivers in the Upper Columbia and Snake River Basins.

Genetic analysis of coho populations provides only limited information on population distinctiveness. In the absence of historical baselines for populations and in light of the extensive nature of hatchery transfers, it is difficult to distinguish natural from anthropogenic genetic patterns. While the genetic variability patterns within the Lower Columbia River ESU have been disrupted, substantial differences still exist between the Lower Columbia and Coastal ESUs. These between ESU differences are useful in detecting the legacy of hatchery transfers across ESU boundaries.

As described in the Introduction of this report (Section 1), the diversity criterion rating for each population was based on the evaluation five diversity elements: 1) Life History Traits, 2) Effective Population Size, 3) Impact of Hatchery Fish, 4) Anthropogenic Mortality and 5) Habitat Diversity). Scores for each of these elements were determined and then combined into a single overall diversity category score for each population. A presentation of these results, population by population, follows next.

DV – Youngs Bay

Life History Traits **–** There are insufficient data to evaluate this diversity element for Youngs Bay coho. However, in light of the likelihood that this population became extirpated in the 1990s, the life history traits of the original wild population have been lost. Therefore, we conclude the persistence score for this diversity element should be zero. Those traits currently expressed by the Youngs Bay population most likely originate from the hatchery strays that now predominate the spawning population. Score = 0.0

Effective Population Size **–** Recent surveys have observed low numbers of natural-origin spawners actual abundance may near 50. Score = –0.5

Hatchery Impacts

> *Hatchery Domestication Index* **–** The Klaskanine Hatchery has been in operation since 1911. A number of coho salmon stocks have been imported into hatchery (because of the introduction of numerous stocks with different propagation histories, the PNI estimates may be somewhat higher). Recent surveys estimate the pHOR at 77.3% (2000-2003), although prior to this it is likely to have been nearer 90%. There is no record of pNOB for the hatchery, but unmarked fish are not "intentionally" included in the broodstock. Genetic analysis of Youngs Bay coho salmon indicate a similarity to other LCR coho salmon populations; however, given the magnitude of hatchery introductions it is unknown if this similarity is related to the natural or hatchery-related factors. PNI ≤ 0.1, Fitness = 0.25. Score = 0.5
>
> *Hatchery Introgression* **–** The vast majority of hatchery-origin strays are from coho released from net pens in Youngs Bay (nearly all of these come from Eagle Creek or other upstream Columbia River hatcheries--Sandy River Hatchery, and Oxbow Hatchery (only 563 tagged coho were recovered since 1990). Score = NA
>
> *Synthetic Approach* – A large number of coho salmon juveniles have been released annually into Youngs Bay and its tributaries for several decades. In general, the majority of these fish originate from outside of the Coastal stratum. Recent estimates indicate that over 75% of the spawning coho salmon observed are of hatchery origin (Ph>0.75) with a low or very low genetic similarity between wild and hatchery fish. Diversity persistence score = 0.0.

Anthropogenic Mortality **–** Although the target of this fishery is earlier returning hatchery fish, it is possible the impact rates on the later returning naturally produced fish are higher than then the 25% estimated for most other LCR coho populations. In addition, the existing fishery exerts a very strong selection against the early portion of the return. Prior to the 1990s the harvest rate was higher, perhaps up to 90%. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 1.0.

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. Loss of estuary habitat types has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this (indicated as a "-" score). Score = 2.0.

Youngs Bay Coho Overall Diversity Score = 0.5.

DV – Big Creek

Life History Traits – There are insufficient data to evaluate this diversity element for Big Creek coho. However, it is likely that this population became extirpated in the 1990s resulting in the loss of the life history traits of the original wild population. Therefore, we conclude the persistence score for this diversity element should be zero. Those traits currently expressed by the Big Creek population most likely originate from the hatchery fish produced at Big Creek hatchery. Score = 0.0.

Effective Population Size – Recent surveys have observed low numbers of natural-origin spawners (zero in some years), actual abundance may have averaged between 50 and 100.Score = 0.5.

Hatchery Impacts

Hatchery Domestication (PNI) – The Big Creek Hatchery has been in operation since 1938. A substantial number of coho salmon have been released into the Big Creek watershed. Big Creek Hatchery does not include unmarked (wild) fish into its broodstock (pNOB= 0), while the pHOR in the Youngs Bay/Big Creek watershed averaged 90% hatchery fish. Genetic analysis of the hatchery broodstock indicates that it is closely related to other LCR coho hatchery stocks. In the last ten years, unmarked coho salmon have been passed over the hatchery weir on Big Creek. This has restored access to a considerable portion of the watershed and created an "all-natural" spawning area above the weir. Returns have numbered a few hundred fish in the last few years. Because of the relatively short duration of this program to date and the long term predominance of hatchery fish in the system, the PNI score was adjusted only slightly to reflect recent conditions. *PNI ≤ 0.2, Fitness = 0.45*

Hatchery Introgression – The vast majority of hatchery-origin strays are from the local Big Creek Hatchery, although a few other within ESU strays have been observed (nearly all hatchery origin coho salmon are marked, but few have origin-source tags).

Synthetic Approach – The Big Creek Hatchery has released a stock of mixed locally-derived and introduced coho salmon for several decades. Few if any wild (unmarked) fish are included in the broodstock and the proportion of hatchery fish spawning naturally has consistently been near 50% (0.30<Ph<0.75) with a low to very low genetic similarity between wild and hatchery fish. Diversity persistence score = 0.5.

Anthropogenic Mortality – Nearby Tongue Point and Blind Slough commercial fisheries potentially have significant impacts on this population. Although the targets of these fisheries are earlier returning hatchery fish, it is possible the impact rates on the naturally produced fish are higher than the 25% estimated for most other LCR populations. In addition, the existing fishery exerts a strong selection against the early portion of the return. Fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0.

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. Loss of estuary habitat types has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this. Score = 2.0.

Big Creek Coho Overall Diversity Score = 1.0.

DV – Clatskanie River

Life History Traits – The paucity of data for this population make the evaluation of this diversity element difficult. However, this population likely went through a severe bottleneck during the 1990s and may have in fact become extirpated. Recent spawning surveys show an increasing number of naturally produced spawners and a relatively low proportion of hatchery fish. The spawn timing of these natural fish appears to be during the November to January time-frame which may be similar to that of the historical coho populations in this region of the lower Columbia. Score = 2.0.

Effective Population Size – Recent surveys have observed low numbers of natural-origin spawners (zero in some years during the 1990s), estimated wild spawner abundance = 74-217 (2002-2004). Score = 2.0.

Hatchery Impacts

Hatchery Domestication (PNI) – The Gnat Creek Hatchery has intermittently released coho salmon. The proportion of hatchery-origin fish has fluctuated considerably, depending, in part, on the intensity of hatchery operations. Genetic analysis of the hatchery broodstock indicates that it is closely related to other LCR coho hatchery stocks. Given the limited level of genetic sampling for this population, it is not possible to discern more population specific information.

PNI ≤ NA, hatchery program intermittent – stray metric used

Hatchery Introgression – The majority of hatchery-origin strays are from local hatcheries producing within ESU coho salmon. Recent stray rates have fluctuated (0 to 67%, average 28.6%). Score = 2.0.

Synthetic Approach – Hatchery coho salmon have not been recently released into the Clatskanie River; however, the proportion of naturally-spawning hatchery fish remains high ($0.10<Ph<0.35$). It is likely that these fish come from nearby hatchery programs (in both Oregon and Washington). Genetic similarity between wild and hatchery-origin fish is presumed to be low. Diversity persistence score =2.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of a 20% to 35% mortality rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically the middle of the run timing. In addition, fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0.

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. Loss of estuary habitat types has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this (indicated as a "-" score). Score = 2.5.

Clatskanie River Coho Overall Diversity Score = 2.0.

DV – Scappoose Creek

Life History Traits – The paucity of data for this population make the evaluation of this diversity element difficult. However, this population likely went through a severe bottleneck during the 1990s and may have in fact become extirpated. Recent spawning surveys show an increasing number of naturally produced spawners and a relatively low proportion of hatchery fish. The spawn timing of these natural fish appears to be during the November to January time-frame which may be similar to that of the historical coho populations in this region of the lower Columbia. Score = 2.0.

Effective Population Size – Scappoose Creek has been surveyed for spawning coho salmon since the late 1940s. Early surveys provide only a rough estimate of total abundance, but it is likely that, on average, over a hundred natural-origin coho salmon return to the basin. Score = 2.0.

Hatchery Impacts

> *Hatchery Domestication (PNI)* – There is no hatchery in the Scappoose Creek Basin. Furthermore, there have been relatively few introductions of coho salmon. During the 1980s, there were widespread releases of coho salmon pre-smolts and surplus hatchery adults, although the survival and spawning success of these fish is thought to have been fairly low. Genetic analysis of natural spawners suggests that this population is somewhat distinct form other populations (potentially because of the minimal hatchery influence or small Ne or both). Score = NA.
>
> *Hatchery Introgression* – The proportion of hatchery-origin fish recovered on the spawning grounds is generally low (<10%). It is probable that most of these hatchery fish are from within the ESU. Score = 2.0.
>
> *Synthetic Approach* – There is no hatchery program in Scappoose Creek, nor has there been one in the past. Additionally, hatchery releases have been limited and intermittent. The proportion of hatchery fish spawning naturally is thought to be low (0.10<Ph), although surveys and carcasses recoveries have been limited. It is likely that many of the hatchery fish originate from the large Washington hatchery programs immediately across the Columbia River. Diversity persistence score =2.0 – 3.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of a 20% to 35% impact rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically the middle of the run timing. In addition, fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0. .

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. Loss of estuary habitat types has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this (indicated as a "-" score). *Diversity.* Score = 2.0.

Scappoose Creek Coho Overall Diversity Score = 2.0.

DV – Clackamas River

Life History Traits – Although this coho population is one of the two in the LCR that is known to have persisted through the poor marine survival period of the 1990s, it was at very low levels during this period and may have experienced the effects of a genetic bottleneck, In addition, the run timing seems to be in a state of flux. The unimodal timing of the early 1960s, shifted to more protracted and bimodal timing by the 1980s. It is not clear if this change was brought on by natural processes impacting the wild population, introduction of a coho stock with earlier run timing in the late 1960s, or selective pressures due to Columbia fisheries or all three. In recent, years it appears the run timing may be returning to a more unimodal pattern more typical of the early 1960s. Score = 3.0.

Effective Population Size – Surveys indicate that several hundred unmarked coho salmon spawned in the Lower Clackamas River from 2002 to 2004, in addition to the several hundred to a few thousand unmarked coho that are passed above the North Fork Dam. It should be noted that the coho run size probably underwent bottlenecks in the mid-1970s and mid-1990s. Further habitat conditions in the lower Clackamas River and associated tributaries (including Johnson and Kellogg Creeks) are generally poor, suggesting that many of these "unmarked" spawners are not the result of natural production, but may be hatchery-origin fish. Score = 3.0.

Hatchery Impacts

Hatchery Domestication (PNI) – The Eagle Creek NFH releases early run coho salmon, and has received a number of transfers from other hatcheries within the ESU. Genetically the Eagle Creek NFH is somewhat similar to the earlier portion of the wild fish returing to the Clackamas River. The Eagle Creek NFH broodstock was founded in 1958 by fish from the Sandy River Hatchery, but has received introductions from a number of other LCR hatcheries. Wild fish are not included in the hatchery broodstock. With the 100% fin marking of all hatchery coho releases in the 1990s, it became evident that hatchery fish (presumably from Eagle Creek hatchery) only rarely entered the Faraday fish ladder in an attempt to stray into the Clackamas basin upstream of North Fork Dam. In recent years those few stray hatchery fish that entered the fish handling Faraday fish handling facility have been removed from the basin, creating a "hatchery-free" zone in the upper basin. However, from 2000-2002 hatchery fish derived from the local wild population were passed upstream of the dams in an effort to supplement the production. Downstream of North Fork Dam, hatchery strays are commonly observed spawning with wild fish. The basin-wide proportion of hatchery strays varies annually, but in recent years it has averaged 0.28. A rough average of 50% was used in the PNI. Hatcheries do not include unmarked "wild" fish into the broodstock. Average hatchery strays (50% below, 5% above) = 25%. *The isolate nature of Eagle River NFH suggests that using the stray metric might be more appropriate. Score = NA.*

Hatchery Introgression – The vast majority of hatchery-origin strays are from the Eagle Creek Hatchery, although a few other within ESU strays have been observed (nearly all hatchery-origin coho salmon are marked, but few have origin-source tags).

The stray metric was used, with an average stray rate of 25% and adjusted for mostly local hatchery broodstock. Score = 2.0.

Synthetic Approach – With the exception of transplants of adult hatchery made in the 1960s and a "conservation hatchery" program in the 1990s, most of the fish spawning above North Fork Dam have been wild fish. In recent years, the few hatchery fish that attempted to migrate past North Fork Dam, have been removed at the fish sorting facility. The hatchery contribution to the naturally-spawning early run is thought to be relatively low ($Ph<0.10$).. The early-returning coho salmon hatchery program (Eagle Creek NFH) has incorporated a coho from a number of sources including locally from the Clackamas River (although they do not presently include unmarked broodstock). Diversity persistence score =2.0 – 3.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of 20% to 35% impact rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically the middle of the run timing. In addition, fishery impact rates in the range of a 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0.

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. The loss of estuary habitat types and mainstem and side channel riparian habitat has been substantial since the mid-1800s. The migratory and juvenile rearing areas include the urbanized portions of the lower Willamette River and Multnomah Channel and Sauvie Island. The diversity scores were adjusted downward to reflect this (indicated as a "-" score). Score = 2.0.

Clackamas River Coho Overall Diversity Score = 2.75.

DV – Sandy River

Life History Traits – Although this coho population is one of the two in the LCR that is known to have persisted through the poor marine survival period of the 1990s, it was at very low levels during this period and may have experienced the effects of a genetic bottleneck, Historical information on run and spawn timing from early in the 1900s is available from hatchery and fisheries records. Comparative information from fish counts made at Marmot Dam and spawning survey information collected from the 2002-2006 suggest that no large changes in life history traits have occurred. Score = 3.0.

Effective Population Size – Spawner abundance estimates are available for Sandy River coho salmon from 1960. The harmonic mean abundance for this period was 499. Historical estimates of abundance suggest that between 10 and 20 thousand coho normally returned to the Sandy River. Score = 3.0.

Hatchery Impacts

Hatchery Domestication (PNI) **–** The impact of hatchery fish in Sandy River Basin is broken into two distinct regions, the watershed above and below Marmot Dam. The area downstream of Marmot Dam represents 10% of the natural coho production area, the remaining 90% is upstream of the dam. The proportion of hatchery fish below Marmot is high, > 80% most years, while upstream of the dam hatchery fish typically represent less than 5% of the spawning population. The basinwide proportion of hatchery fish in recent years has been less than 0.10. Accessible habitat below Marmot Dam contains a mixture of hatchery and natural-origin fish, and accessible habitat above Marmot Dam contains unmarked "wild" fish. The watershed below Marmot Dam accounts for less than 20% of the currently accessible habitat, hatchery contribution varies and carcass recovery is low, estimated pHOR ≥ 75% and the pNOB ≤ 5%. The Sandy River Hatchery has been in operation since 1953, with relatively few introductions from out-of-basin. However, wild fish have not been routinely added to the hatchery broodstock. Genetic analysis does not indicate any strong divergence from other Lower Columbia River populations, or any similarity to coho salmon from other ESUs. *PNI =1.0 (above dam), PNI=0.1 (below dam), 18 generations. Score = 2.0.*

Hatchery Introgression – HOR fish from the Sandy River Hatchery were considered part of the population and their effect was considered in the PNI metric. Out of basin strays are generally rare. Score = 3-4.

Synthetic Approach – The Sandy River Basin is contains two distinct regions relative to the influence of hatchery-origin fish. Since 1999, hatchery-origin fish have been blocked from migrating past the Marmot Dam trap, while the area below the Dam contains a very high proportion of hatchery origin fish (nearly 80%). The area downstream of Marmot Dam represents 10% of the natural coho production area, the remaining 90% is upstream of the dam. The basinwide proportion of hatchery fish in recent years has been less than 0.10. The Sandy River Hatchery has been in operation since 1953, with relatively few introductions from out-of-basin; however, wild (unmarked) fish have not been routinely added to the hatchery broodstock. Genetic similarity is thought to be low to moderate. Diversity persistence score =3.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of a 20% to 35% impact rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically in the later portion of the run timing. In addition, fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0

Habitat Diversity – The habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. The loss of estuary habitat types and mainstem and side channel riparian habitat has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this (indicated as a "-" score).

Score = 1.5.

Sandy River Coho Overall Diversity Score = 2.5.

DV – Lower Gorge Tributaries

Life History Traits – Streams on the Oregon side of the Lower Columbia River Gorge contain relatively little accessible spawning habitat. Historically, there was little effort made to survey these streams, but it appears that late-run coho salmon occupied the habitat. There are insufficient data to evaluate this diversity element for this population of coho. However, it is likely this population became extirpated in the 1990s resulting in the loss of the life history traits of the original wild population. Therefore, we conclude the persistence score for this diversity element should be zero. Those traits currently expressed by this population most likely originate from the hatchery strays from the Bonneville hatchery complex that now predominate the spawning population.

Score = 0.0.

Effective Population Size – Abundance estimates for Oregon side of the Lower Columbia River Gorge population are based on only 5% of the accessible habitat. The estimated average abundance of the naturally produced fish in this population is at critically low levels, N < 50. Additionally, this limited number of spawners is spread across a number of smaller tributaries. Score = 0.5.

Hatchery Impacts

> *Hatchery Domestication (PNI)* **–** Tributaries in the Lower Columbia River Gorge population contain a high proportion of hatchery strays. These hatchery fish originated from broodstock of multiple origins, from both within and outside of the gorge stratum. No wild fish are incorporated into the broodstock. The proportion of hatchery coho on the spawning grounds in recent years has been in excess of 0.80. Score = 0.0 Tributaries in the Lower Columbia River Gorge population contain a high proportion of hatchery strays (pHOR ≥ 80%) probably from one of a number of Bonneville complex hatcheries (all of which have highly varied broodstock sources). There is little information available on the pNOB for these hatcheries, but based on the relative proportion of unmarked fish in the overall population pNOB ≤ 10%. PNI =0.1 with an estimated 20 generations. Fitness loss near 65%. Score = 1.0.
>
> *Hatchery Introgression* – Given the variety of broodstock sources used in hatcheries that have influenced this population it is possible to evaluate hatchery influence using either the PNI metric or the within ESU stray metric. In either case the diversity score would indicate a high degree of risk. Stray Rate Metric = 1 (if used in place of the PNI metric)
>
> *Synthetic Approach* – The Lower Gorge Tributaries are thought to be heavily influenced by large releases of hatchery coho salmon from Bonneville Hatchery on the Oregon side and a number of hatcheries on the Washington side. The broodstock for these hatcheries are generally of mixed-stock origin from basins within the Lower Columbia River. Estimates of hatchery-origin contribution to spawning escapement are in excess of 75% (Ph,0.75). Diversity persistence score = 0.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of a 20% to 35% impact rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically in the later portion of the run timing. In addition, fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0.

Habitat Diversity – The total amount and diversity of habitat available to the natural coho population in this region is extremely limited, even in its native state. Therefore, the net score was downgraded to reflect this fact. In addition,the habitat diversity index scores derived from the worksheet do not include habitat in the Columbia River estuary. The loss of estuary habitat types and mainstem and side channel riparian habitat has been substantial since the mid-1800s. The diversity scores were adjusted downward to reflect this effect as well. Score = 0.5.

Lower Gorge Tributaries Coho Overall Diversity Score = 0.5.

DV – Hood River/Upper Gorge Tributaries

Life History Traits – Coho salmon exist in this population at a very depressed level of abundance. Historical and present-day information is very limited, and primarily concerns run and spawn timing. Coho salmon in the short, low lying, Gorge tributaries appear to exhibit a late-run timing, while fish entering the Hood River Basin may represent an early-run timed run. There are insufficient data to evaluate this diversity element for this population of coho. However, it is possible that wild coho were extirpated during 1990s, causing the loss of the life history traits of the original wild population. Therefore, we conclude the persistence score for this diversity element should be zero. Those traits currently expressed by this population most likely originate from the hatchery strays from the Bonneville hatchery complex that now predominate the spawning population. Score = 0.0.

Effective Population Size – Abundance estimates for Oregon side of the Upper Columbia River Gorge population are based on only 5% of the accessible habitat. The estimated average abundance of NORs in the Gorge tributaries is at a low level, $N < 50$. Additionally, this limited number of spawners is spread across a number of smaller tributaries. Fish counts at Powerdale Dam, on the Hood River, indicate that the coho run has averaged below 50 fish in the last 15 years. Score = 1.0.

Hatchery Impacts

> *Hatchery Domestication (PNI)* **–** Tributaries in the Upper Columbia River Gorge population contain a high proportion of hatchery fish (pHOR ≥ 80%) that are likely strays from the Bonneville hatchery complex. These hatchery stocks were developed from a number of sources both within and outside of the stratum. Further, wild fish are not used as a portion of the hatchery broodstock. The proportion of hatchery coho on the spawning grounds in recent years has been in excess of 0.80. Score = 0.0. There is little information available on the pNOB for these hatcheries, but based on the relative proportion of unmarked fish in the overall population pNOB ≤ 10%.
>
> *PNI =1.0 with an estimated 20 generations. Fitness loss near 65%. Score = 1.0.*
>
> *Hatchery Introgression* – Stray hatchery fish come from a variety of sources. Local hatcheries contain broodstocks that have been strongly influenced by a number of out-of-basin sources. Calculation of hatchery effects could be done either using the PNI metric or the within ESU metric.
>
> *Stray Rate Metric = 1 (if the PNI metric is not used).*
>
> *Synthetic Approach* – As with the Lower Gorge Tributaries, spawning aggregations in the Upper Gorge Tributaries are thought to be heavily influenced by large releases of hatchery coho salmon from Bonneville Hatchery on the Oregon side and a number of hatcheries on the Washington side. The broodstock for these hatcheries are generally of mixed-stock origin from basins within the Lower Columbia River. Estimates of hatchery-origin contribution to spawning escapement are in excess of 75% (Ph,0.75). Diversity persistence score = 0.0.

Anthropogenic Mortality – Mainstem Columbia and ocean fisheries exert a moderate impact on this population, probably in the range of a 20% to 35% impact rate. However, the timing of the Columbia River fisheries are thought to select against those portions of the population that return during what was historically in the later portion of the run timing. In addition, fishery impact rates in the range of 75% to 90% were experienced by this population from the 1950s to the early 1990s. It is unknown what the legacy of this impact has been on the genetic character of the populations. Score = 2.0..

Habitat Diversity – Much of the spawning habitat for coho salmon in the Upper Gorge DIP was flooded with the filling of the Bonneville Pool. Within the Hood River basin, the historically highest quality coho habitat has been adversely impacted by agricultural and urban development. Score = 1.0.

Hood River/Upper Gorge Tributaries Coho Overall Diversity Score = 1.0.

DV – Criterion Summary

With the exception of the Clackamas and Sandy populations, it is likely that most of the wild LCR coho populations were effectively extirpated in the 1990s. Therefore, the genetic diversity of the original wild populations was nearly lost. Although naturally produced fish have reappeared in recent years (particularly the Scappoose and Clatskanie basins), their lineage is unclear. In the case of the Youngs Bay, Big Creek, Lower and Upper Gorge populations, the current situation where 80%+ of the natural spawners are stray hatchery fish, makes the re-establishment of a self-sustaining, locally adapted wild population unlikely in the future. Better prospects are evident for the Clatskanie and Scappoose populations where the incidence of stray hatchery fish is much lower. The net assessment of the diversity criterion for each population is represented by the diamonds in Figure 48. As described in the Introduction (Section 1) of this report, these diamonds were constructed on the basis of the most likely high, low and mode score for each criterion. The mode score (widest portion of the diamonds in Figure 48) corresponds with the DV rating for each population. High and low values (corresponding with the tops and bottoms of the diamonds in Figure 48) were subjectively determined on the basis that the confidence in the accuracy of the DV rating was low for all populations. The Youngs Bay, Big Creek, and both Gorge Tributaries population most likely fall into the high risk category for this criterion (Figure 48). The most probable classification for the remaining populations is the moderate risk category, although both the Sandy and Clackamas populations are nearly in the low risk category.

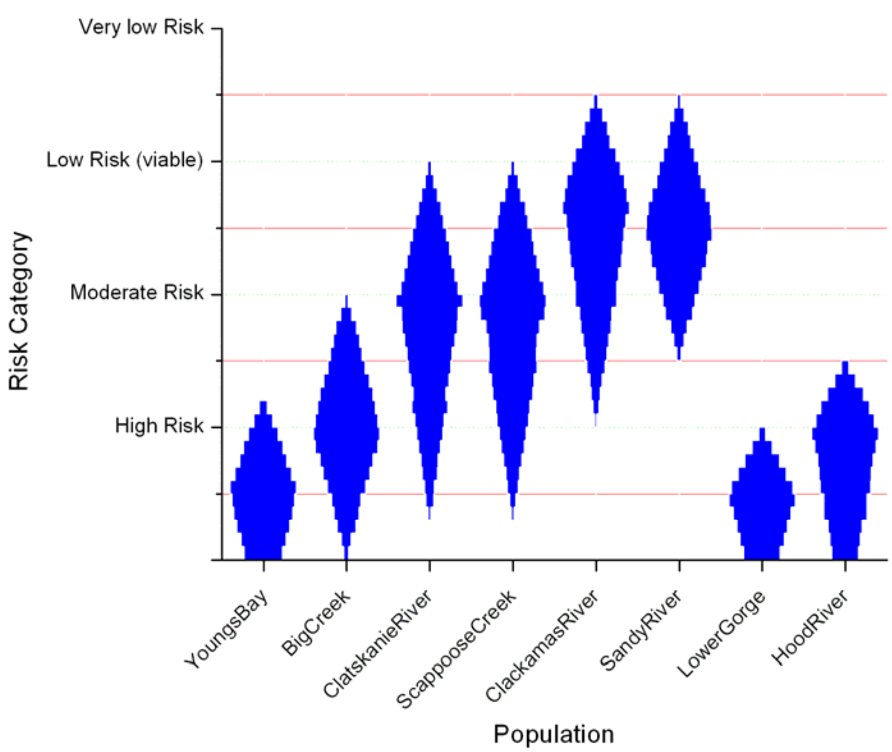


Figure 45: Lower Columbia River coho risk summary based on the evaluation of diversity only.

V. Summary of Population Results

The Clackamas is the only population in Oregon's portion of this ESU that is most likely in the viable category (Figure 46 and Figure 47). The Sandy has population is most likely in the high risk category, but the range of possible risk categories is from very high risk to viable. The remaining populations are clearly in the high or very high risk categories. Even though both the Clatskanie and Scappoose populations show encouraging signs in recent years, the risk of extinction for coho in Oregon's portion of the lower Columbia remains high.

The status of Washington populations is still under assessment; however there is no evidence that self-sustaining populations of wild coho survived the poor marine survival period of the 1990s. When the condition of coho populations on both sides of the Columbia is considered together, the picture is even bleaker. Only one population in the entire ESU—the Clackamas—is approaching viability. It is apparent that no viable populations exist in either the Coast or Gorge stratum. Although a final ESU score is not possible until the assessment of Washington coho populations is complete, we expect that the final score to place this ESU in the high risk category.

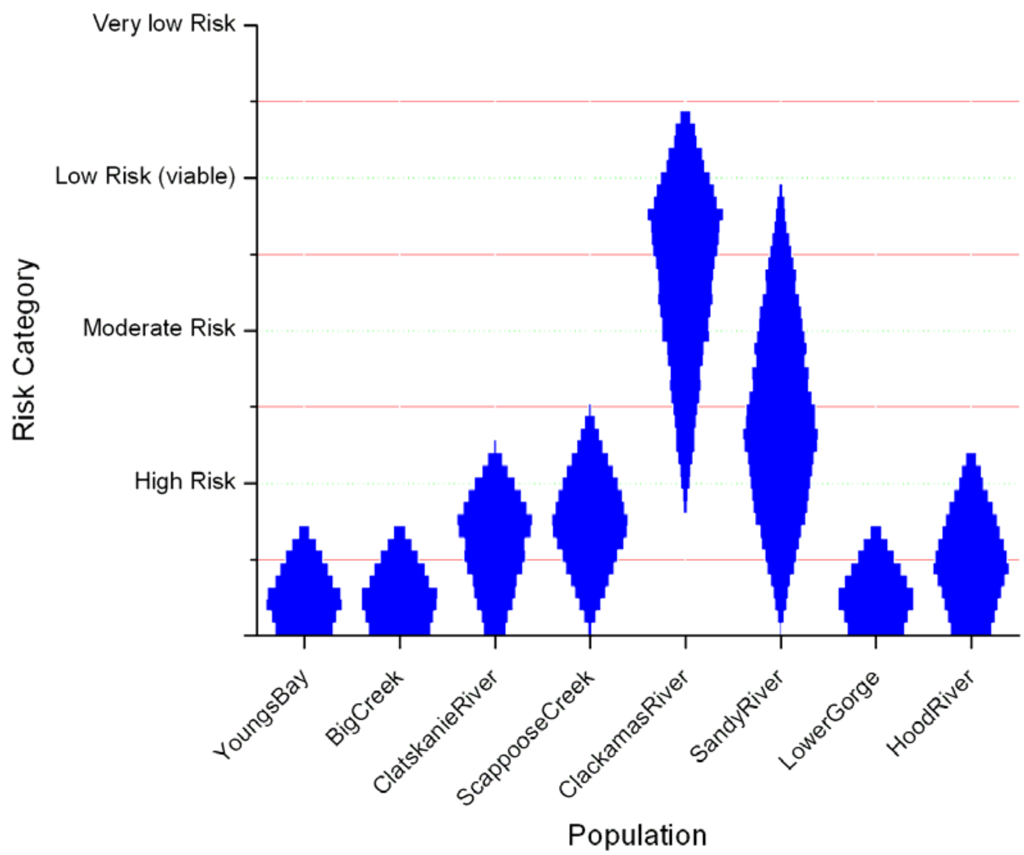


Figure 46: Oregon LCR coho population status summaries based on minimum attribute score method.

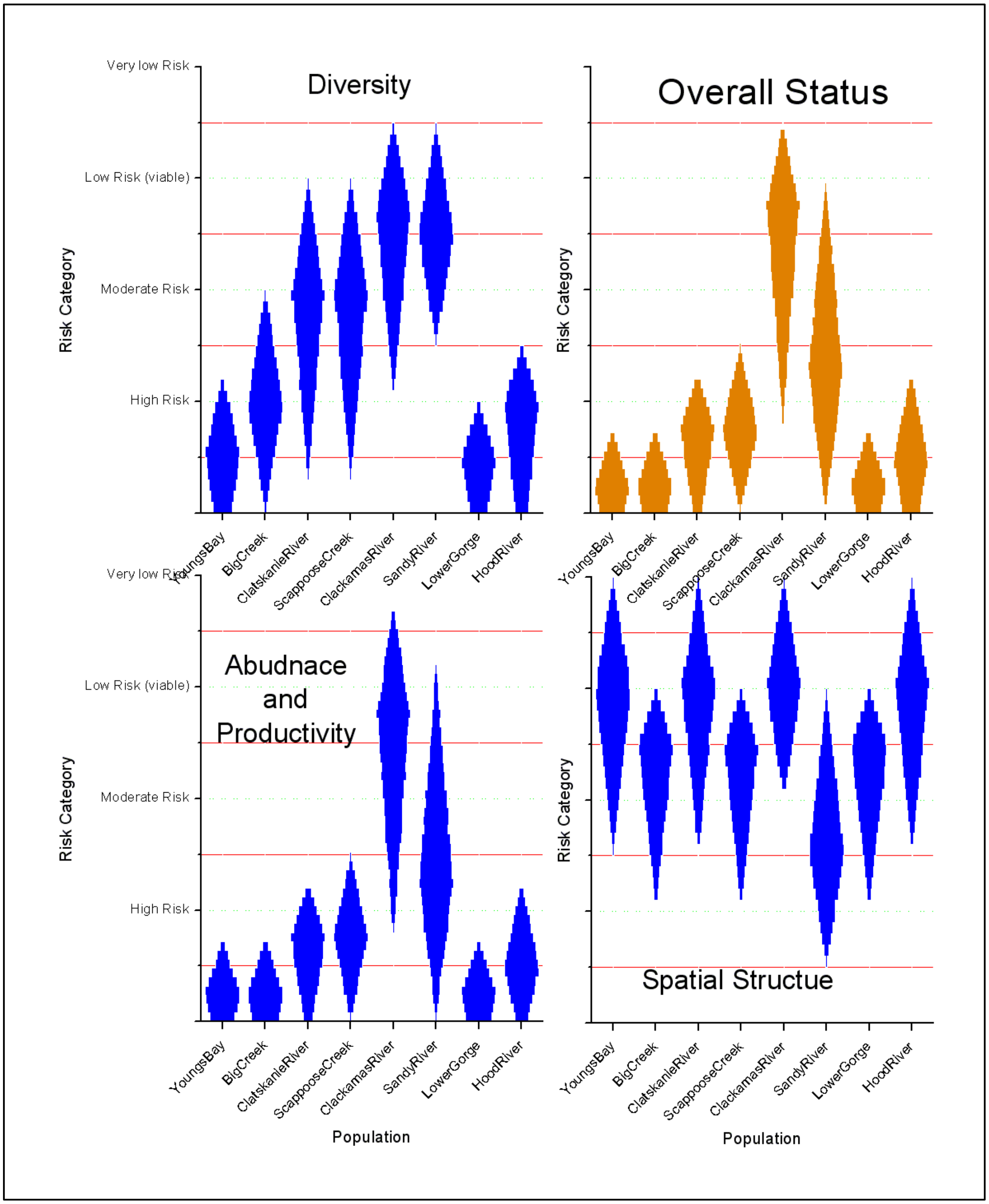


Figure 47: Oregon Lower Columbia River coho salmon status graphs and overall summary.

Literature Cited

Chapman, D.W. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Trans. Am. Fish. Soc. 115:662-670.

Chilcote, M.W. 1999. Conservation status of lower Columbia River coho salmon. Oregon Department of Fish and Wildlife, Fish Division Information Report 99-3, 41p. Oregon Department of Fish and Wildlife, Portland, Oregon.

Myers, J. M., C. Busack, D. Rawding, A. R. Marshall, D. J. Teel, D. M. Van Doornik, and M. T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. NMFS-NWFSC-73, NOAA NWFSC, Seattle, WA.

ODFW. 2005. 2005 Oregon native fish status report. ODFW, Salem, OR.

Olsen, E. A. 2004. Hood River and Pelton ladder evaluation studies. Project No. 198805304 BPA Report DOE/BP-0004001-3), BPA.

Sheer, M. 2007. Update to Maher (2005) maps based on personal communication with ODFW biologist Mark Chilcote and others. NOAA-NWFSC. Seattle, WA

Suring, E. J., E. T. Brown, and K. M. S. Moore. 2006. Lower Columbia River coho status report 2002-2004: population abundance, distribution, run timing, and hatchery influence. Oregon Department of Fish and Wildlife, Corvalis, OR.